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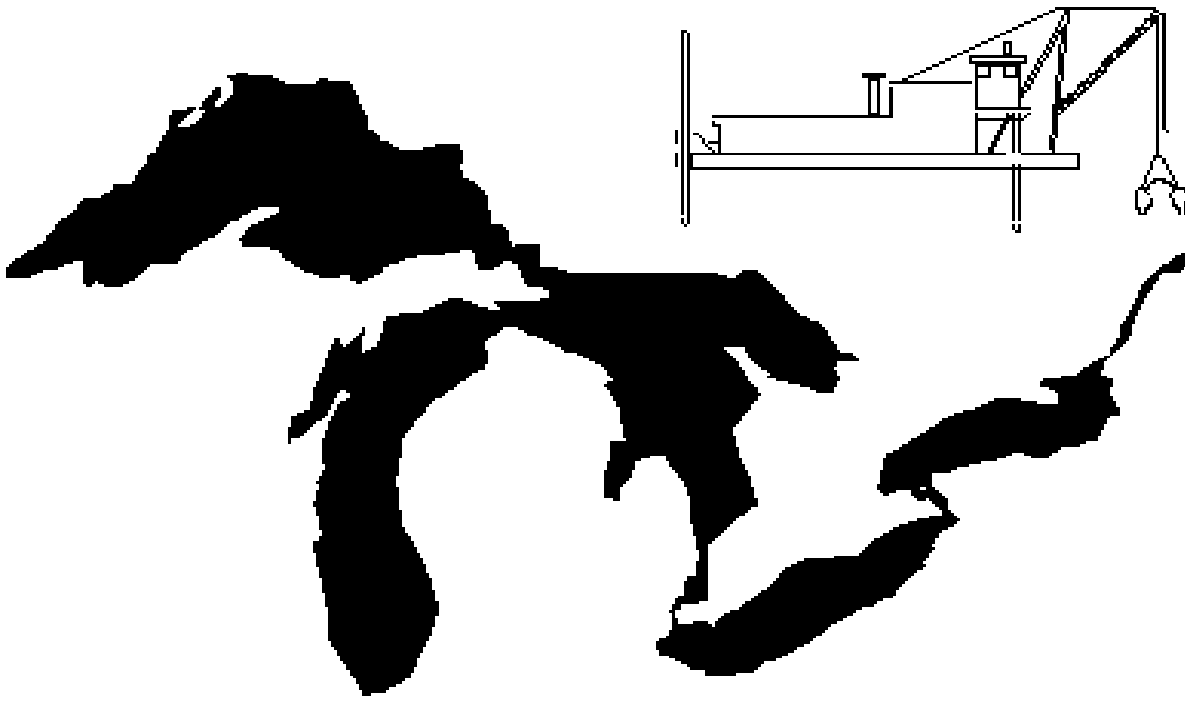
Great Lakes Dredged Material Testing and Evaluation Manual



GREAT LAKES
DREDGED MATERIAL TESTING AND EVALUATION MANUAL

Prepared by:

U.S. Environmental Protection Agency
Regions 2, 3, 5, and
Great Lakes National Program Office

and

U.S. Army Corps of Engineers
Great Lakes & Ohio River Division

FINAL DRAFT

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DISCLAIMER

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This manual was prepared by the USEPA/USACE Great Lakes 404(b)(1) Task Group. The members of this Task Group are as follows:

Mr. Dennis Anderson	USACE, St. Paul District
Dr. Gary Ankley	USEPA, Environmental Research Laboratory - Duluth
Mr. Mark Barath	USEPA, Region 3
Dr. Patricia Boone	USEPA, Region 5
Mr. John Dorkin	USEPA, Region 5
Mr. Al Fenedick	USEPA, Region 5
Mr. Steve Garbaciak	USACE, Great Lakes National Program Office[a]
Ms. Pam Horner	USACE, Detroit District
Mr. Alex Lechich	USEPA, Region 2[2]
Mr. David Melfi	USACE, Buffalo District
Mr. Jan Miller	USACE, Great Lakes & Ohio River Division
Mr. Scott Pickard	USACE, Buffalo District
Mr. Jay Semmler	USACE, Chicago District
Mr. Frank Snitz	USACE, Detroit District[a]
Dr. Marc Tuchman	USEPA, Great Lakes National Program Office
Dr. Thomas Wright	USACE, Waterways Experiment Station[a]
Mr. Howard Zar	USEPA, Region 5

The co-chairs of the Task Group are Dr. Marc Tuchman and Mr. Jan Miller. In addition to the above Task Group members, valuable support was provided by the following:

Dr. Larry Brooke	Lake Superior Research Institute
Dr. Daniel Call	Lake Superior Research Institute
Ms. Joan Clarke	USACE, Waterways Experiment Station
Dr. Tom Dillon	USACE, Waterways Experiment Station[a]
Dr. David Moore	USACE, Waterways Experiment Station[2]
Mr. Mario Paula	USEPA, Region 2
Dr. Brian Schumacher	USEPA, Environmental Monitoring Systems Laboratory
Mr. George Schupp	USEPA, Region 5[a]
Ms. Kathy Schroer	USEPA, Region 5
Ms. Ann Strong	USACE, Waterways Experiment Station
Mr. Richard Sutton	USACE, Chicago District[a]
Mr. Matthew Williams	USEPA, Region 5
Ms. Jennifer Wolf	USEPA, Region 5[a]

[a] Affiliation no longer current.

PREFACE

The availability of the draft Great Lakes Dredged Material Testing and Evaluation Manual for public review and comment was announced in the Federal Register on December 19, 1994. Approximately 500 copies of the draft were distributed. A synopsis of the general comments received is provided below. These comments were evaluated by the USEPA and USACE. In order to save printing and distribution costs, the entire manual will not be reprinted. Only those pages that have been modified to address review comments and the recent revision to the Section 404(b)(1) Guidelines will be distributed to recipients of the draft manual for insertion in the manual. With these changes, the manual is finalized and ready for implementation.

Comments were received from State agencies, lake user groups, consulting firms and environmental interest groups. One comment recommended that the manual provide dredging performance requirements. Another recommended that the manual provide testing guidance for fill materials as well as dredged material. While regional guidance on these areas would be worthwhile, it is beyond the intended scope of this manual. The USEPA and USACE are working toward joint guidance on a variety of issues related to dredged material management on a national level. On a regional level, the USEPA and USACE will continue together to address priority issues related to dredging and dredged material management.

Some comments indicated misunderstandings as to the applicability of the manual. This manual provides guidance that is to be used in evaluations conducted under Section 404(b)(1) of the Clean Water Act. The Clean Water Act does not apply in Canadian waters of the Great Lakes. The guidance in this manual does not bind States as far as their authority under Section 401 of the Clean Water Act, although it was the intent of the developers of this manual that the testing procedures provide the information necessary for States to make decisions regarding Section 401 certification.

A comment was received questioning why the manual did not address the sampling of sediments beneath those to be dredged, as these sediments would be exposed by the dredging operation. The potential impacts of sediments exposed by dredging may be a relevant issue to be addressed in the overall 404(b)(1) evaluation or in an environmental assessment/impact statement. However, this manual has focused on only a part of the 404(b)(1) evaluation, that dealing with contaminant related impacts of dredged material discharges.

Navigation users commented on the length of the document, complexity of the evaluation and costs of biological tests as adversely impacting the maritime industry. In contrast, some environmental interest groups criticized the tiered testing system as sacrificing protection for cost-savings. Throughout the development of this manual, the USEPA and USACE have attempted to balance these conflicting concerns.

The USEPA and USACE concur that there will be some short-term increases in costs with the implementation of this manual, particularly from the use of biological toxicity and bioaccumulation tests. However, we believe that in the long run the manual will help standardize the decision making process, and make the management of dredged material more predictable. This should help navigation interests better plan their dredging activities. The improvements in quality assurance and documentation which are included in the manual should also enable long-term decisions to be made based on test results, and reduce the need to test a project every time it is dredged. Biological effects-based tests have been utilized routinely for ocean disposal decision making for almost 20 years without a significant adverse impact on navigation.

The USEPA and USACE do not believe that a tiered testing approach sacrifices the interests of environmental protection. This approach is more systematic and reasoned than requiring all tests for all materials, and focuses the evaluation at dredged materials that have a greater likelihood of causing contaminant impacts. For those dredged material where there is reason to believe contaminant impacts might result, the biological effects-based tests recommended in this manual represent a scientifically sound and environmentally protective basis for decision making.

A related comment suggested that dredged material be analyzed for, at a minimum, all of the bioaccumulative contaminants of concern (BCC) identified in the Great Lakes Initiative. The manual does, in fact, reference the BCC list for consideration in developing contaminant of concern lists (page 26). But the agencies believe that it is more reasonable to develop site specific lists of contaminants of concern that reflect local conditions and sources of contamination, rather than to apply a "standard list" of contaminants to all sites and situations.

Several comments were received regarding the definition and use of reference sediment. Since the release of the draft manual, the USEPA published proposed rulemaking related to the 404(b)(1) Guidelines in the Federal Register on 1/4/95. The substance of this rulemaking was to include a definition of reference sediment comparable to that already used in ocean

disposal regulations. The draft of this manual had utilized the reference sediment definition, anticipating the rulemaking would occur before this manual was finalized. Finalization of this rulemaking has been delayed. Because of the uncertainty regarding the rulemaking, this regional guidance document will be finalized consistent with the existing Guidelines which do not include a definition of reference sediment. The existing Guidelines specify that dredged material are evaluated compared to sediment from the disposal site. As most open water disposal sites in the Great Lakes are dispersive in nature, this manual will encourage a broad interpretation of "disposal site."

Two reviewers proposed that additional testing methods be incorporated into the manual. It remains the intent of the USEPA and USACE that this manual be a "living document" and that it be updated periodically to incorporate new or modified testing procedures. Before new methods can be incorporated, they must be fully evaluated for appropriateness to this regulatory program. The evaluation and documentation of testing methods currently in the manual required substantial time and effort, and it was not considered appropriate to delay the finalization of this manual while other methods were evaluated. The methodologies proposed by reviewers will be considered for inclusion in the first update to this manual.

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1. INTRODUCTION

1.1 Purpose

This manual presents guidance on testing and evaluation for proposed discharges of dredged material into the United States waters of the Great Lakes Basin.

1.2 Authority

The U.S. Environmental Protection Agency (USEPA) Regions 2, 3, and 5, and U.S. Army Corps of Engineers (USACE) North Central Division, have jointly prepared this regional guidance under the authority provided in 40 CFR (Code of Federal Regulations) Section 230.2(c), pursuant to the requirements of Section 404(b)(1) of the Clean Water Act (CWA), Public Law 92-500. This regional guidance is consistent with the national guidance presented in Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (USEPA/USACE, 1998), also known as the "Inland Testing Manual."

1.3 Applicability

These guidance are applicable to all proposed discharges of dredged material to the United States waters of the Great Lakes Basin. This includes disposal operations conducted under Section 404 permits issued by the USACE or authorized State agency, as well as Federal projects conducted by the USACE.

Issues relevant to the identification and delineation of wetlands are outside the scope of this manual. In addition, this manual does not provide guidance on the identification of disposal sites for dredged material. Guidance on the selection of disposal sites is provided in "Evaluating environmental effects of dredged material management alternatives--A technical framework" (USACE/USEPA 1992).

This manual will not, in general, address concerns with fill material. The rationale for this omission is that the evaluation and testing described herein is focused upon chemical contaminants. Fill material, such as stone or soil from commercial sources, is not usually a significant carrier of contaminants. Exceptions to this may be specific fill materials which could be carriers of chemical contaminants or when dredged material is used for fill. This manual will also not address the impacts of the excavation or dredging activities during a

dredging and disposal operation.

The testing and evaluation procedures described herein provide only a portion of the information necessary for a complete evaluation of a proposed dredged or fill material discharge, as required by Section 404(b)(1). These testing procedures are directed at the "contaminant determination" portion (40 CFR 230.11(d)) of the larger 404(b)(1) evaluation, although the information obtained through these testing procedures are relevant to other determinations. The final determination of acceptability of any proposed discharge of dredged material also considers the probable impact, including cumulative impacts of the proposed discharge, on the public interest.

The evaluation and testing guidance in this manual will be effective on August 1, 1998 and will be reevaluated at least every five years and revised as necessary by the USEPA in conjunction with the USACE. It is intended that this manual be a "living document" and that additional guidance and updates to evaluation procedures be distributed for incorporation as available.

1.4 Definitions

Acronyms and abbreviations used in this manual are listed in Appendix A. Definitions of terms used are provided in Appendix B. The following definitions are included here because of their importance to understanding the scope and content of this manual.

The **Great Lakes** and **Great Lakes Basin** refers to the United States waters of Lakes Michigan, Superior, Huron, Erie, Ontario, the connecting channels, St. Lawrence River, their tributaries and any other waterbodies within the United States watersheds of these Lakes.

Discharges of dredged material refers to the discharge of dredged material to waters of the United States and includes discharges of water from dredged material disposal operations including beach nourishment, upland, or confined disposal which return to waters of the United States.

Guidelines refers to the Section 404(b)(1) regulations found in 40 CFR 230.

The term **guidance** may refer to either national or regional implementation manuals developed to assist the evaluator in making a contaminant determination as defined in 404(b)(1) Guidelines.

Disposal site is that portion of the United States waters where specific disposal activities are proposed or permitted. It consists of a bottom surface area and all overlying water, if present. If the disposal site is dispersive in nature (e.g., an area subject to currents or wave energies sufficient to transport dredged material), the disposal site might (for purposes of obtaining a sediment sample) be considered to include areas adjoining the immediate disposal location. Regional guidance on the collection of sediment sample(s) from the disposal site is provided in paragraph 4.3.2 and Appendix D.

1.5 History of National Guidelines and Guidance

The discharge of dredged or fill materials to waters of the United States is regulated under Section 404 of the Clean Water Act (CWA), Public Law 92-500. An evaluation of a proposed discharge of dredged or fill materials must be completed in compliance with Section 404(b)(1) of this Act, pursuant to 40 CFR 230.10. Compliance is determined by the Secretary of the Army acting through the Chief of Engineers, and is based upon the 404(b)(1) Guidelines promulgated by the Administrator of the USEPA in conjunction with the USACE.

The first Guidelines were issued in 1975 and, pursuant to these Guidelines, the USACE published an interim guidance manual entitled "Ecological evaluation of proposed discharge of dredged or fill material into navigable waters" (USACE 1976). The amendments to the CWA in 1977 and experience gained between 1975 and 1980 led to a revision of these Guidelines. This revision, at 40 CFR 230, became a final rule on December 24, 1980.

A key component in determining compliance with the Guidelines is the evaluation and testing procedure for the material proposed for discharge pursuant to 40 CFR 230.60 and 230.61. These procedures had been addressed in the interim guidance manual in 1976 and revised procedures were provided on December 24, 1980, as a proposed rule. The final rule specified, at 40 CFR 230.61, that the chemical, physical, and biological evaluation and testing that were based upon the 1975 Guidelines remain in effect until final rule-making. Although a final rule has yet to be issued, additional experience gained since 1980 has indicated that the 1976 manual is in need of revision.

In 1990, the USEPA and USACE began efforts to update the 1976 national guidance manual. The updated national manual has proceeded in parallel with the development of this regional guidance for the Great Lakes.

1.6 History of Regional Guidance

The Guidelines and national guidance are general in nature and lack some of the specificity appropriate for project-specific evaluations. Under 40 CFR 230.2(c), regional guidance on the implementation of 404(b)(1) Guidelines may be developed by the USEPA in conjunction with the USACE. Prior to the development of this regional guidance manual, no previous guidance for testing dredged material for proposed discharge to the Great Lakes had been developed under this authority.

The USEPA and USACE have used criteria and guidelines based on the physical and chemical properties of dredged material to make decisions about discharges to the Great Lakes since the late 1960's. The "Jensen criteria" were a list of numerical levels for seven sediment physical and chemical parameters to be used in the evaluation of dredging projects in fresh and marine waters. These criteria were disseminated by the USEPA Headquarters in early 1971, prior to the 1972 Clean Water Act.

These "Jensen criteria" were used in the Great Lakes to determine which dredged material required disposal to a confined disposal facility (CDF), constructed under Section 123 of PL 91-611 (Rivers and Harbors and Flood Control Act of 1970). These "criteria" were modified by Region 5, USEPA, in 1974, allowing for a determination based on the collective information and not any single pass-fail number. In 1977, the USEPA, Region 5, published "Interim guidelines for the pollutional classification of Great Lakes harbor sediments" (USEPA 1977). These guidelines expanded the "Jensen criteria" to a system for classifying sediments as non-polluted, moderately polluted, and heavily polluted based on 19 physical and chemical parameters.

In 1982, the Dredging Subcommittee to the Great Lakes Water Quality Board of the International Joint Commission published "Guidelines and register for evaluation of Great Lakes dredging projects" (IJC 1982). This report presented recommendations for evaluation of dredged material which were generally consistent with the 404(b)(1) Guidelines and USEPA's 1980 proposed testing procedures. A tiered testing procedure was recommended, utilizing historical information, sediment chemistry and elutriate testing, and sediment bioassessment. This report stated that "standardized procedures must be developed for conducting bioassays and bioaccumulation studies" and "meaningful criteria must be adopted to evaluate bioassay results".

Dredged material evaluations on the Great Lakes have relied almost entirely on sediment chemical testing for many years, largely because of the lack of standardized biological testing procedures or interpretive guidance. The need for regional

guidance on dredged material evaluation and testing, pursuant to 40 CFR 230.2(c) was identified by the USEPA and USACE. A USEPA/USACE task group was formed in 1990 to develop the regional guidance presented in this manual. The members of this task group are listed in the Acknowledgements.

1.7 Use of the Manual

This regional testing and evaluation manual should be used to supplement the national testing and evaluation guidance in accordance with the 404(b)(1) Guidelines (40 CFR 230). **The user of this regional guidance should have read and be familiar with the "Inland Testing Manual" (USEPA/USACE 1998) and the 404(b)(1) Guidelines in their entirety.**

Applicants for Section 404 permits for proposed discharges of dredged material into the United States waters of the Great Lakes should consult the appropriate District office of the USACE before implementing the testing procedures described in this manual. The USACE District will provide assistance on the applicability of this manual to the proposed discharge, the applicability of any regional or nation-wide general permits, in locating existing data, and other requirements of the Section 404 process.

Nation-wide Section 404 permits have been issued for a limited number of specific categories of dredged material and fill discharges that are similar in nature and have minimal impacts (33 CFR 330). The testing requirements for these discharges may differ from those described in this manual. Permit applicants should contact the appropriate USACE District on the applicability of these nation-wide permits to the proposed discharge.

Compliance with the provisions of Section 404 of the Clean Water Act does not eliminate the need to comply with the requirements of other Federal and State environmental laws and regulations.

1.8 Points of Contact for Section 404 permit applications

The Section 404 permit program for the United States waters of the Great Lakes is managed by four district offices of the USACE. The territories of these districts are shown on figure 1. The mailing addresses, telephone and fax numbers for these offices are as follows:

U.S. Army Corps of Engineers Buffalo District, CELRB-CO-R 1776 Niagara Street Buffalo, NY 14207-3199 Phone: (716)-879-4330 Fax: (716)-879-4310	Portions of the Great Lakes Basin within New York, Pennsylvania and Ohio
U.S. Army Corps of Engineers Chicago District, CELRC-CO-R 111 North Canal Street Chicago, IL 60606-7206 Phone: (312)-353-6400 Fax: (312)-353-2141	Portions of the Great Lakes Basin within Illinois
U.S. Army Corps of Engineers Detroit District, CELRE-CO-L P.O. Box 1027 Detroit, MI 48231-1027 Phone: (313)-226-2432 Fax: (313)-226-6763	Portions of the Great Lakes Basin within Indiana and Michigan
U.S. Army Corps of Engineers St. Paul District, CEMVP-CO-R 190 5th Street East St. Paul, MN 55101-1638 Phone: (612)-290-5375 Fax: (612)-290-5330	Portions of the Great Lakes Basin within Wisconsin and Minnesota

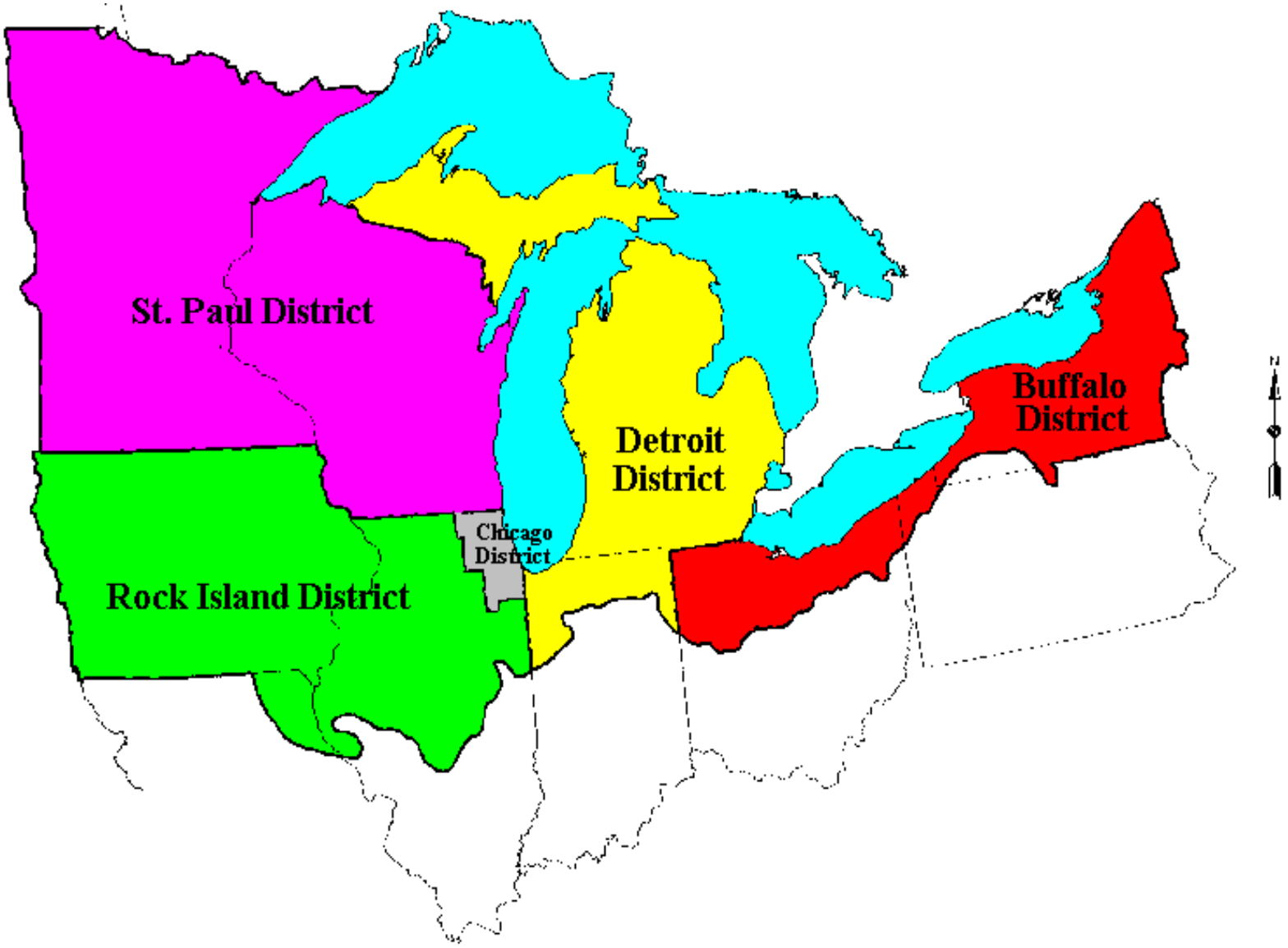

Figure 1. Map of USACE Regulatory Boundaries within the Great Lakes Basin

Section 404(g) of the Clean Water Act allows the USEPA to transfer a portion of the regulatory program for Section 404 to a qualifying State or Indian Tribe. The State or Tribe needs to have sufficient legislative and regulatory infrastructure to be capable of this responsibility. The State or Tribe can assume Section 404 permitting responsibility for any water that is not also a Rivers and Harbor Act Section 10 water based on certain criteria. The USEPA retains oversight authority, and the USACE has some review authority on major permit actions.

The only delegation of Section 404 permitting authority to a Great Lakes State is with the State of Michigan. Memoranda of Agreement between the State of Michigan and the USEPA and USACE were signed in 1983 and 1984, respectively. The Michigan Department of Natural Resources (DNR) issues Section 404 permits for most interior lakes, streams and isolated waters, including wetlands, within the State.

2. TESTING APPROACH

The tiered approach to testing used in this manual is consistent with the national manual (USEPA/USACE 1994), but provides more detailed guidance specifically for the Great Lakes. The reader is referred to the national manual for a more detailed discussion of the tiered approach. The tiered testing approach is consistent with the testing procedures used for ocean disposal of dredged material under Section 103 of the Marine Protection, Research and Sanctuaries Act (MPRSA) (USEPA/USACE, 1991), and is also generally consistent with the "Guidelines for project evaluation" developed by the International Joint Commission (IJC 1982).

The objective of the tiered testing approach is to make optimal use of resources in generating the information necessary to make a contaminant determination, using an integrated chemical, physical, and biological approach. To achieve this objective, the procedures in this manual are arranged in a series of tiers with increasing levels of intensity. The initial tier uses available information that may be sufficient for completing the evaluation in some cases. Evaluation at successive tiers requires information from tests of increasing sophistication and cost.

The basic flow diagram for the tiered testing procedure is shown on figure 2. The most logical and cost efficient approach is to enter Tier 1 and proceed as far as necessary to make a determination. There are two possible conclusions that can be made at each of the first three tiers: 1) available information **is not** sufficient to make a contaminant determination, or 2)

available information **is** sufficient to make a contaminant determination. Where information is sufficient, one of the following determinations may be reached: a) the proposed discharge **will not** have unsuitable, adverse, contaminant-related impacts, or b) the proposed discharge **will** have unsuitable, adverse, contaminant-related impacts

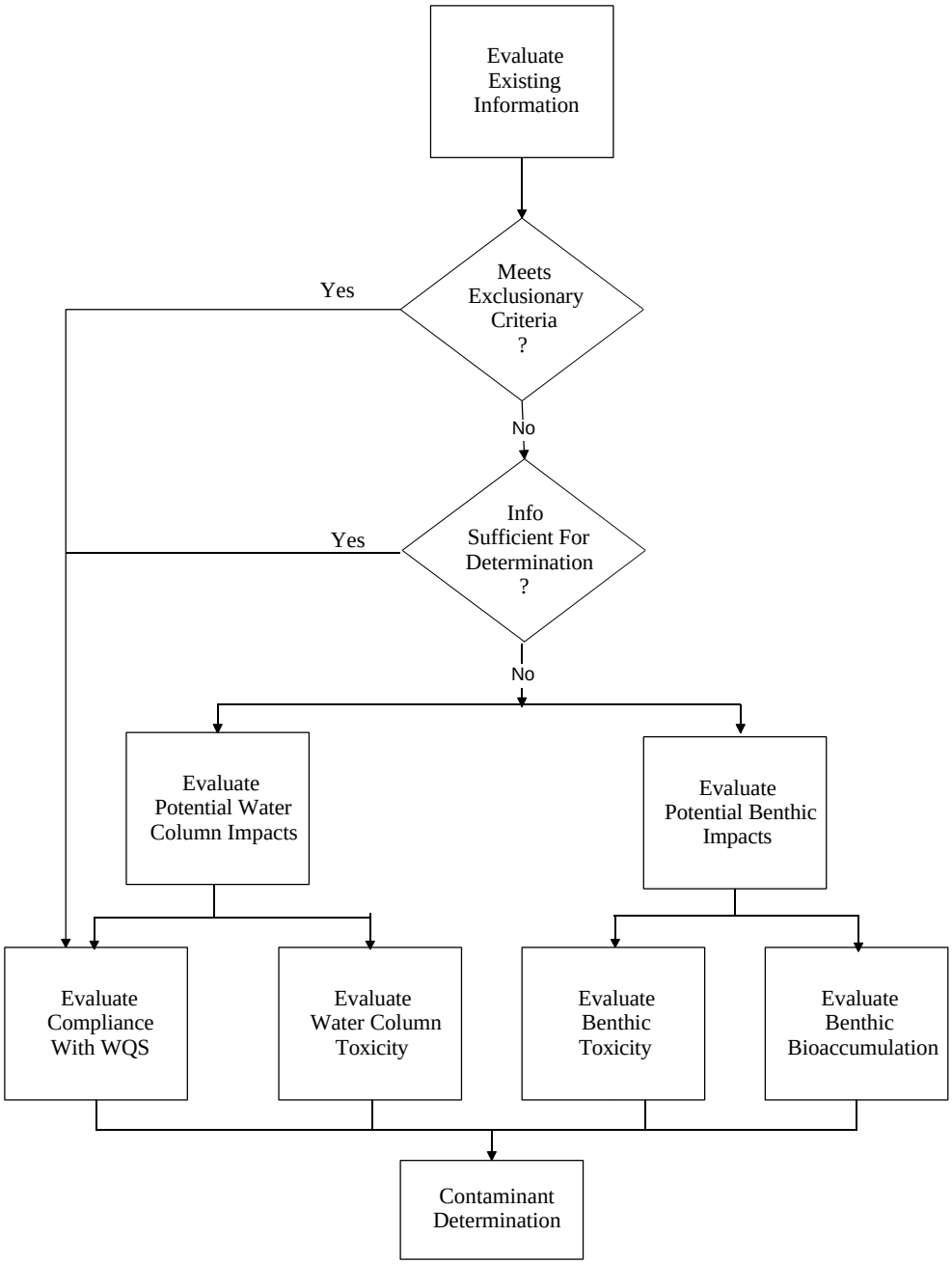

Figure 2. Tiered Testing Flow Diagram

Tier 1 compiles existing information about the potential for contamination in the proposed dredged material. Disposal operations that are excluded from testing or have historic data sufficient for the contaminant determination may proceed to a determination without additional testing.

Tier 2 evaluates the potential impacts of the proposed discharge on water column and benthic environments using sediment physical and chemical data collected for this tier, and applied with computer models to project worst-case conditions for water quality impacts and bioaccumulation. Based on the results of Tier 2 evaluations, additional testing may be reduced or eliminated.

Tier 3 evaluates the potential impacts of the proposed discharge on water column and benthic environments using effects-based biological testing. This manual presents recommended procedures for biological-effects tests with six organisms. These tests have been determined to be appropriate for use in the Great Lakes Basin.

Tier 4 is only entered if the information provided by Tiers 1 through 3 is not sufficient to make a contaminant determination. The procedures used in Tier 4 are keyed to site specific issues not resolved by the standardized procedures of earlier tiers. It is intended that very few situations will require a Tier 4 evaluation.

With this tiered testing structure, it is not necessary to obtain data for all tiers to make a contaminant determination. It may also not be necessary to conduct every test described within a given tier to have sufficient information for a determination. The underlying philosophy is that only that data necessary for a determination should be acquired.

3. TIER 1

3.1 Purposes

One of the purposes of Tier 1 (figure 3) is to determine whether a contaminant determination can be made on the basis of existing information. The compilation of existing information about the dredged material excavation site and proposed disposal site will serve as the basis for determining if a decision can be made without additional testing.

Another purpose of Tier 1 is the identification of the contaminants of concern, if any, in the dredged material. The identification of contaminants of concern will help determine

what, if any, testing should be conducted in subsequent tiers.

The initial focus of the Tier 1 evaluation is to obtain information relevant to sections 230.60 (a), (b), (c), and (d) of the Guidelines, and relevant to the potential for contaminant-associated impacts from the proposed discharge. These four sections of the Guidelines define exclusions from testing. A Tier 1 evaluation should be completed even if these exclusions are not likely to be satisfied, since the information compiled will be needed to determine which, if any, tests should be conducted in subsequent tier(s).

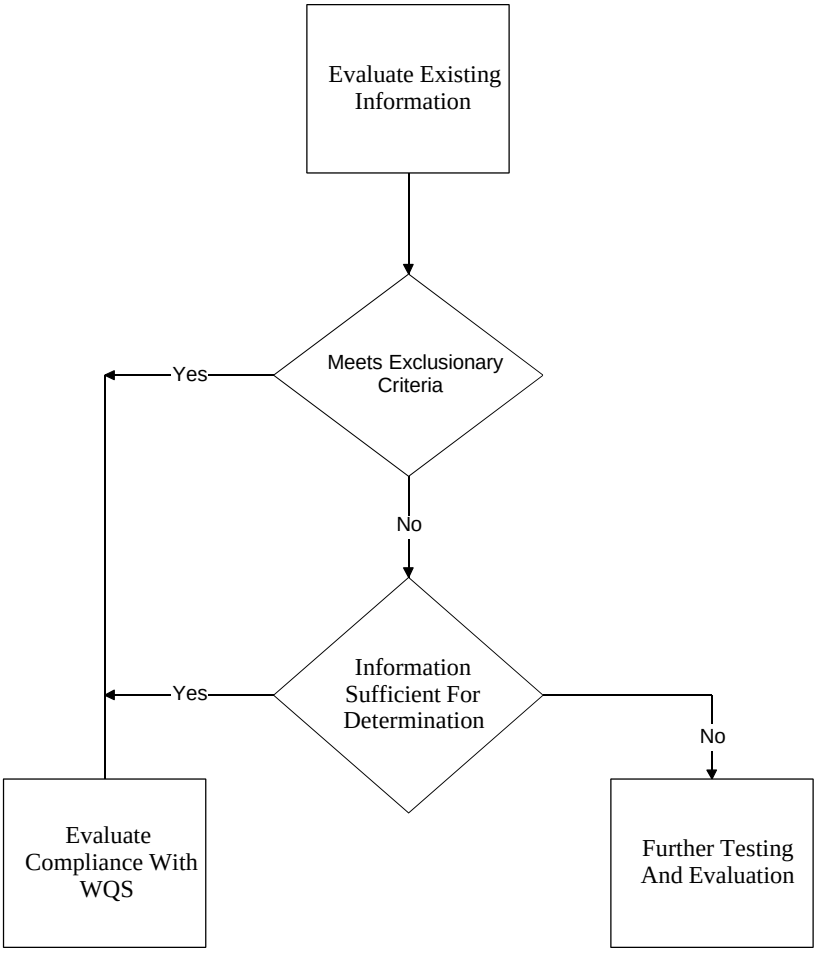

Figure 3. Tier 1 Flow Diagram

3.2 Planning and Coordination

Interagency coordination is essential to the development of a 404(b)(1) evaluation and a legal requirement under the National

Environmental Policy Act of 1969 (PL 91-190). Such coordination is critical in the Tier 1 evaluation process, where available information must be compiled from a variety of sources. Evaluators are encouraged to solicit input from other agencies on data sources, potential contaminants of concern, and proposed sampling and testing. Coordination prior to initiation of sampling and testing will reduce the chance of having to repeat costly procedures and assist in keeping projects on schedule.

3.3 Compilation of Available Information

A survey of contaminant sources and pathways should be conducted for the proposed dredging site. Section 230.60(b) of the Guidelines lists a number of factors that should be considered when evaluating the potential for contamination at the dredging site. These factors represent sources of contamination, pathways of contaminant transport, and naturally occurring substances which may be harmful to aquatic biota. In order to assess the potential for contamination at a proposed dredging site, information on these factors must be evaluated. A more complete inventory of available information will increase the likelihood that decisions concerning the impacts of dredged material may be made without unnecessary testing.

3.3.1 Contaminant Sources and Pathways

There are a number of potential sources of sediment contamination, both anthropogenic and natural. These sources include:

- urban and agricultural runoff,
- sewer overflows/bypassing,
- industrial and municipal wastewater discharges,
- previous dredged or fill material discharges,
- landfill leachate/groundwater discharge,
- spills of oil or chemicals,
- illegal discharges,
- air deposition,
- biological production (detritus), and
- mineral deposits.

Different sources and combinations of sources may contribute differing types and quantities of contaminants to sediments. A matrix of commonly accepted correlations between source types and specific contaminants is provided in figure 4. This matrix is not all inclusive and makes no accounting for current pollution control practices. It should be used as guidance only.

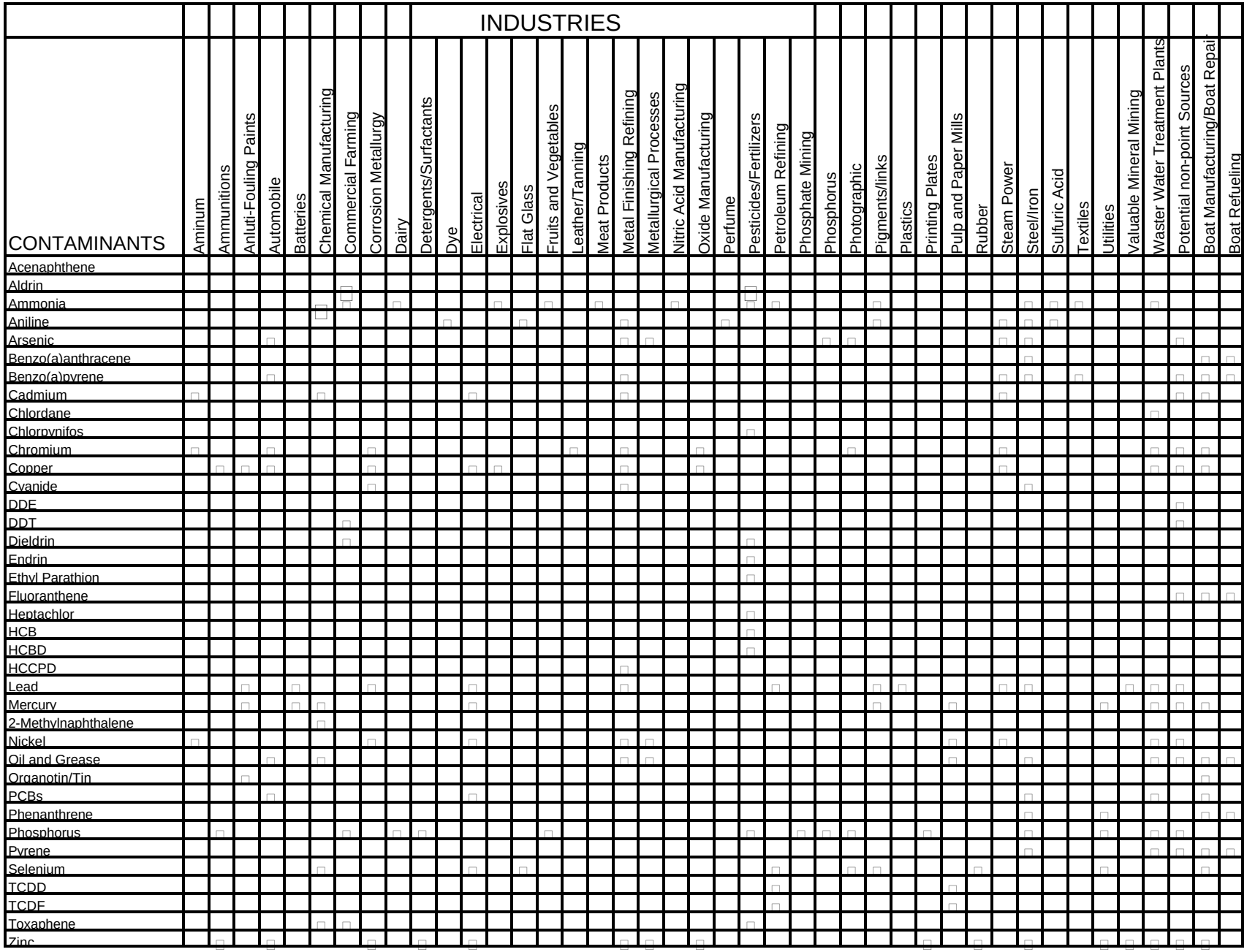

Figure 4. Sediment - Contaminant Source Matrix

There are also a number of factors which influence the pathways between these contaminant sources and the dredging and/or disposal sites. These factors include:

- bathymetry,
- water current patterns,
- wind patterns and local meteorology,
- tributary flows,
- watershed hydrology and land uses,
- sediment and soil types, and
- sediment deposition rates.

3.3.2 Sources of Information

There is a potentially large amount of historical information relevant to sources of sediment contamination available from Federal, State and local agencies, as well as in the open literature. A partial listing of these data sources for areas of the Great Lakes basin are provided in Appendix C.

Sediment quality data are routinely collected by the USACE at many of the authorized navigation projects in the Great Lakes. Much of this database is physical and chemical data with limited biological test results. Sediment data has also been collected by other agencies and investigators. A listing of available data reports is provided in Appendix C.

A number of computer databases are maintained by the USEPA which contain information on known sources of chemical contamination. Most of these databases are maintained by regulatory or clean-up programs such as NPDES and Superfund. Fact sheets for selected computer databases, showing the types of information available and how to access the data are provided in Appendix C. These databases include:

- STORET (STOrage and RETrieval system),
- TRI (Toxic Chemical Release Inventory),
- PCS (Permit Compliance System),
- RCRIS (Resource, Conservation, and Recovery Act Information System),
- ESDC (Environmental Sciences Division Clearinghouse),
- Niagara Frontier Program Office GIS Pilot Project,
- GRIDS (Geographic Resources Information and Data System),
- R5SI (Region 5 Sediment Inventory), and
- other specialized databases.

Ambient water quality data are routinely collected by State resource agencies at a number of locations throughout the Great Lakes and tributaries. These data are commonly reported on an annual or biennial basis in documents published by these

agencies. A listing of these reports and the agency points of contact is provided in Appendix C.

There are 31 Areas of Concern (AOCs) within the United States portion of the Great Lakes basin identified in the Great Lakes Water Quality Agreement. The locations of these AOCs are listed in Appendix C. State resource agencies are developing Remedial Action Plans (RAPs) for these sites. These RAPs are a useful source of information about sources of contamination.

Additional information on sources of contamination in the Great Lakes is provided in the list of published reports provided in Appendix C. These publications may be found in many libraries or through the libraries of some agencies. Local and regional agencies which should be contacted for more site specific information include:

- regional planning commissions,
- county and municipal governments,
- port/marina authorities, and
- State resource/survey agencies.

When utilizing available data, the evaluator should consider the quality of the information and its applicability for making decisions.

3.3.3 Data Acquisition

With the proliferation of computer databases and electronic information capabilities, evaluators may actually face a problem of having too much data rather than not enough. For example, when retrieving data from the STORET computer database, the zone of inquiry may be defined as a circle with the center at the dredging site and a variable radius, a polygon, or a watershed boundary. Other databases may retrieve information along political boundaries (county or State). An excessively large zone of inquiry will often yield an unwieldy amount of data not relevant to the evaluation.

The size of the zone of inquiry should be determined using the information obtained about possible routes of contaminant transport to the dredging and disposal sites. These routes should be defined before initiating computer database searches. In general, the zone of inquiry for potential sources of sediment contamination should be larger for a dredging site in a tributary stream than for a dredging site in the coastal lacustrine area of a Great Lake. Sediments in a riverine setting are more likely to have been exposed to sources of contaminants from different portions of the watershed, many miles from the river channel. This is especially true for non-point sources of contamination

such as urban and agricultural runoff. In contrast, contaminants from most sources in the coastal areas away from tributary outlets are more readily dispersed and diluted, and less likely to impact nearby sediments.

The quality of historic data should be assessed to determine its usability. Limited guidance on the quality assessment of historic data is provided in Appendix E. In general, the weight of evidence can only be determined by best professional judgement.

3.4 Exclusions From Testing

Sections 230.60 (a) and (b) state that if an evaluation of the extraction (dredging) site indicates that the dredged material is not a "carrier of contaminants", the determination of the presence or effects of contaminants can be made without testing. The Guidelines further states that, "Dredged or fill material is most likely to be free from chemical, biological, or other pollutants where it is composed primarily of sand, gravel and other inert materials."

The compilation of existing information described above (paragraph 3.3) will be used to determine the applicability of this exclusion. Dredged material that are most likely to meet this exclusion include sediments from locations which are far removed from most anthropogenic activities or sediments from depths deposited in pre-industrial times and not exposed to modern sources of pollution. However, the potential impacts from natural mineral deposits should also be considered.

Section 230.60 (c) states that testing will not be required "where the discharge site is adjacent to the excavation site and subject to the same sources of contaminants, and materials at the two sites are substantially similar". This exclusion applies even if the dredged material is a carrier of contaminants providing that "dissolved materials and suspended particulates can be controlled to prevent carrying pollutants to less contaminated areas".

A large number of the dredging operations on the Great Lakes remove sediments from the entrances to protected harbors and marinas along the lakefront. In most cases, the material excavated is fine-grained sand that is transported around the near shore areas by littoral processes and deposits in artificially deepened navigation channels. A hypothetical example of this condition is shown on figure 5. In most cases, the dredged material are disposed to the open lake adjacent to the harbor/marina or onto an adjacent beach.

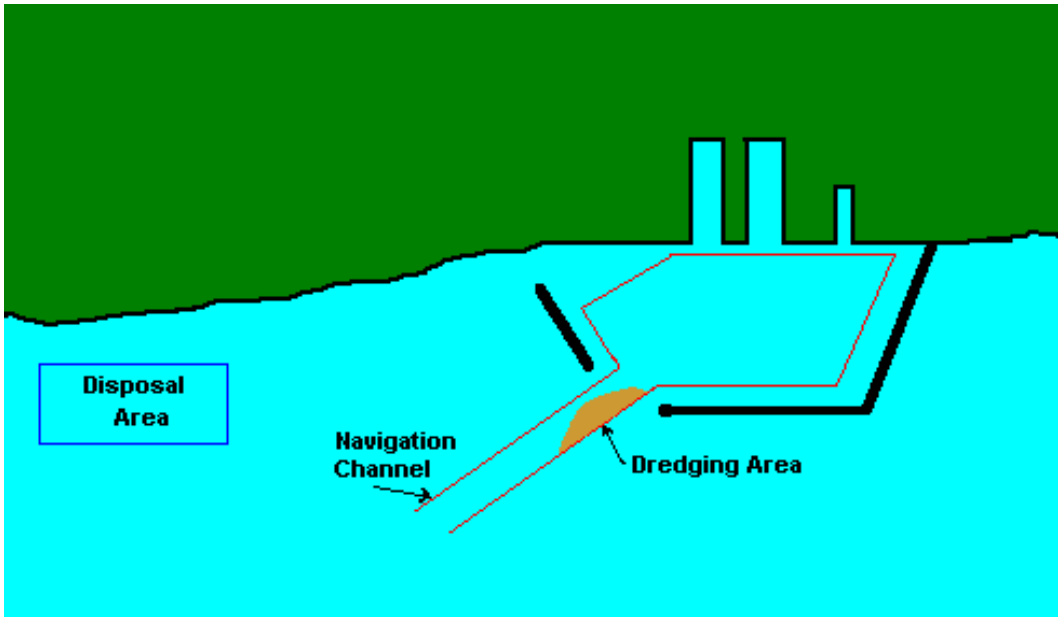

Figure 5. Example Dredging/Disposal Scenario

In this example, the dredging site and disposal site are part of the same littoral system. Where sediments at the dredging site and disposal site are equally exposed to sources of contamination and are shown to be physically and chemically similar, such discharges meet the requirements of the 230.60 (c) exclusion from testing when dredged material pollutants (if any) can be prevented from being transported to less contaminated areas.

Limited physical and chemical testing will generally be necessary to confirm that the sediments from the dredging site and disposal site are physically and chemically similar. Physical testing usually requires a particle size distribution (sieve) analysis. Chemical testing is required for the contaminants of concern identified in paragraph 3.5. Guidance on sediment sampling and analyses is provided in paragraph 4.3.

The 230.60(c) exclusion does not apply when the sediments from the dredging and disposal sites are chemically or physically dissimilar. In the example shown on figure 6, the tributary may have exposed the sediments at the dredging sites to more sources of contamination than the disposal site. It is also possible that the tributary could cause the sediments at the dredging sites to be more fine-grained than the sediments at the disposal site.

Section 230.60 (d) states that testing may not be necessary with material likely to be a carrier of contaminants if constraints acceptable to the USACE District Engineer and USEPA Regional Administrator are available to "reduce contamination to

acceptable levels within the disposal site and to prevent contaminants from being transported beyond the boundaries of the disposal site."

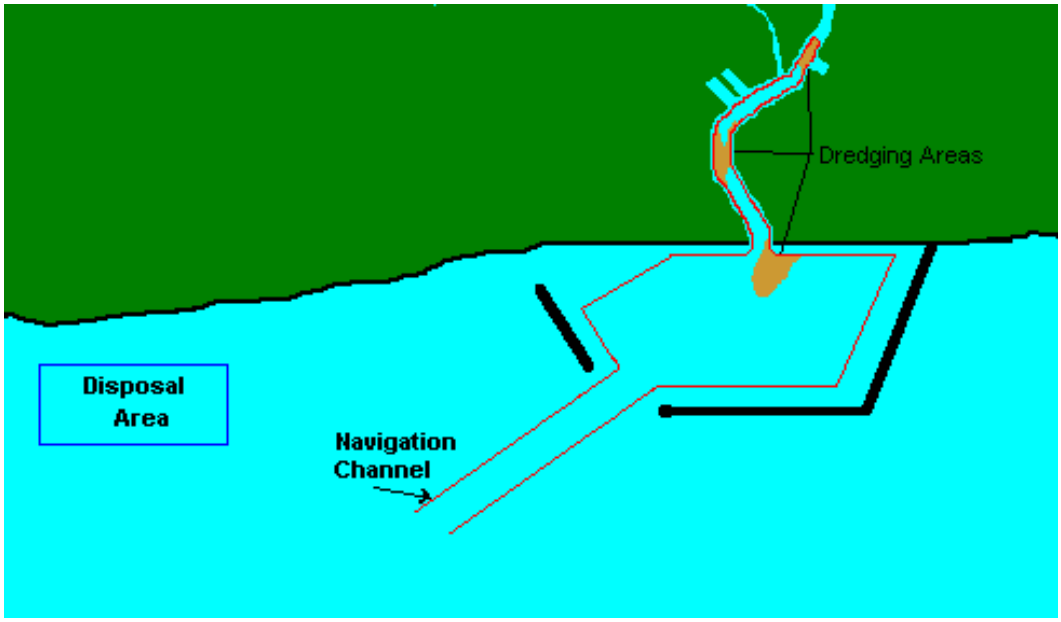

Figure 6. Example Dredging/Disposal Scenario

Technologies for capping and underwater containment of dredged material have been developed and practiced on the east and west coasts for several years (Zeman et al. 1992; Palermo 1991, 1991b). In addition, treatment technologies for contaminated sediments have been evaluated and demonstrated (Averett et al. 1990; USEPA 1994). In order to be subject to an exclusion under 230.6(d), the performance and monitoring requirements for these technologies will need to be developed by the USACE and USEPA on a case-by-case basis. These dredged material management options are outside the scope of this manual.

3.5 Identification of Contaminants of Concern

The purpose of identifying contaminants of concern in each dredged material is to determine parameters for testing in later tiers, if necessary. A contaminant of concern should be identified on the basis of the following factors:

- presence in the dredged material,
- concentration in the dredged material relative to the concentration in sediments at the disposal site,
- toxicological importance,
- persistence in the environment,
- propensity to bioaccumulate from sediments, and
- presence on applicable fish consumption advisory.

To aid in the identification of contaminants of concern for individual projects, the USEPA and USACE have developed the generic list of contaminants shown on table 1. This list is applicable to Great Lakes sediments, but is not all inclusive. The list was developed with consideration of the above factors using historical sediment data, known sources of contamination, and is generally consistent with the IJC guidelines (IJC 1982).

Table 1. Generic list of physical and chemical parameters for characterizing Great Lakes sediments

Arsenic	Total organic carbon (TOC)
Cadmium	Total volatile solids (TVS)
Chromium	Total phosphorous
Copper	Ammonia-nitrogen
Lead	Total petroleum hydrocarbons (TPH)
Mercury	Polychlorinated biphenyls (PCBs)
Nickel	
Zinc	

Routine physical analysis should include grain size and percent solids. All chemical analysis should be reported on a dry weight basis.

This generic list of contaminants of concern should serve as a starting place and not necessarily as the final list. Information compiled on a specific project, as described above (paragraph 3.3) should be used to supplement or reduce the chemical parameters on the generic list. The reasons for supplementing or reducing this list should be fully documented.

As an example, the contaminant of concern list for a dredged material located in a river downstream of a steelmaking plant or coking operation should be expanded to include polynuclear aromatic hydrocarbons (PAHs), which are commonly associated with discharges from these industries. For another project, if there were historical data indicating the absence of mercury in sediments from the project and no suspected sources, this parameter should be removed from the list. With dredging projects covering large areas, it may be possible to have different contaminants of concern for two or more portions of the proposed dredging area.

In situations where there are fish consumption advisories, the responsible bioaccumulative contaminants that are the source of the advisory should be considered for the list of contaminants of concern. A summary of recent State fish advisories and a listing of State agency contacts is provided in Appendix C.

3.6 Contaminant Determination

After consideration of all available information, one of the following two possible **conclusions** can be reached at Tier 1:

1 - Existing information does not provide a sufficient basis for making a contaminant determination. In this case, further evaluation at a higher tier is appropriate.

2 - Existing information does provide a basis for making a contaminant determination. In this case, one of the following three **determinations** may be reached:

a) The dredged material meets the exclusion criteria and no further information on contaminants is necessary to determine compliance (except for information necessary for Section 401 compliance - see paragraph 4.5.3).

b) The dredged material does not comply with the exclusion criteria, but the available information is sufficient to show the material is not a carrier of contamination to a degree which will cause an unsuitable, adverse impact.

c) The dredged material does not comply with the exclusion criteria, but the available information is sufficient to show the material is a carrier of contamination to a degree which will cause an unsuitable, adverse impact.

Sediment data may include results from previous tiered analyses. For many projects, the same areas are dredged routinely and discharged to the same site. In such cases the results of previous tiered testing may be used to reach a decision in Tier 1.

For projects with recurring maintenance dredging, a Tier 1 evaluation is not necessarily required for each dredging and discharge operation. A comprehensive Tier 1 evaluation should require only minor updating on a periodic basis to determine if additional data or evaluation is necessary. This reevaluation of the Tier 1 analysis should consist of the collection and examination of available information on any changes in contaminant sources or pathways to the dredging and discharge sites. It is recommended that the Tier 1 evaluation be updated at least every three years for frequently dredged projects and prior to each operation for projects dredged less frequently.

In navigation projects that cover a large area, it is common that only selected portions are dredged at any one time. While a

full Tier 1 evaluation should initially be conducted for the entire project, a Tier 1 reevaluation and determination of compliance may be performed for only a portion of the larger navigation project for individual dredging operations.

At the completion of Tier 1, even if a decision is made to exclude the dredged material from testing or that existing information is sufficient to make a contaminant determination, additional testing may be necessary to obtain a certification of water quality compliance, as required under Section 401 of the CWA. While the requirements for 401 certification are determined by the applicable State agency, the procedures described in paragraph 4.5 of this manual should address water quality compliance. A scenario under which no additional testing may be necessary for water quality certification is one in which the dredged material meets exclusion 230.60 (a) and (b) because there are no contaminants of concern.

3.7 Reporting

Much of the information gathered under Tier 1 will be condensed in the 404(b)(1) evaluation document. Because a comprehensive Tier 1 evaluation will likely gather far more information than can be presented in the 404(b)(1) evaluation, and because of the importance of the decisions made at this tier, it is recommended that this information be documented in supporting materials and referenced as appropriate in the 404(b)(1) evaluation.

The report of the Tier 1 evaluation should summarize the following information:

- potential sources of sediment contamination identified,
- sources of information investigated,
- historic sediment data (physical, chemical, biological),
- contaminant pathways to dredging and discharge sites,
- reasons for applying exclusions from testing,
- results of any confirmatory testing,
- contaminants of concern list,
- reasons for the final list of contaminants of concern, and
- QA/QC documentation supportive of critical data.

This documentation should be developed into a report that can be distributed for State and Federal agency review and if necessary, inserted as an appendix to the 404(b)(1) evaluation public review document. A well documented Tier 1 evaluation will expedite future 404(b)(1) evaluations at the same project or any new dredging projects in the vicinity.

4. TIER 2 - PHYSICAL AND CHEMICAL TESTING

4.1 Purpose

Within the tiered structure, the purpose of Tier 2 (figure 7) is to make a contaminant determination using dredged material physical and chemical data collected for this tier. However, not all decisions can be made in this tier. Tier 2 utilizes calculations and/or models to predict the potential for dredged material contaminant impacts in the water column and benthic environments, and is intended to provide a reliable, rapid screening tool to determine when the more costly biological testing is necessary.

There are two situations under which the evaluator will enter Tier 2. The first is having completed Tier 1 with insufficient information to reach a determination. The second is having completed Tier 1 with sufficient information for a contaminant determination or exclude material from testing, but additional data is necessary for Section 401 certification.

At the present time, the state-of-the-art of Tier 2 evaluation is rather limited. Our ability to predict toxicological and bioaccumulation impacts based on sediment chemical data is not sufficient to reach a determination in most cases. Despite these limitations, Tier 2 will provide information necessary to determine water quality compliance for Section 401 and may reduce the scope of future testing.

4.2 Planning and Coordination

The purpose of sediment sampling and analysis in Tier 2 is to obtain the necessary physical, chemical and elutriate data for evaluating potential water column and benthic impacts from sediment contaminants with the screening methods of this tier. The existing information compiled in Tier 1 (paragraph 3.3) is the logical starting point for planning a sediment sampling and testing program. This information should, in most cases, be adequate to determine the scope of sediment sampling and analysis. The contaminant of concern list developed in Tier 1 identifies the chemical parameters for analyses.

It is possible to conduct sediment sampling and analysis for Tier 1 (confirmatory testing only), for Tier 2 (physical and chemical testing), for Section 401 compliance, and Tier 3 (biological testing) as either separate or combined activities. The costs of multiple sediment sampling events, allowable sample holding times, and project time and funding constraints should be considered when developing a sampling and analysis plan.

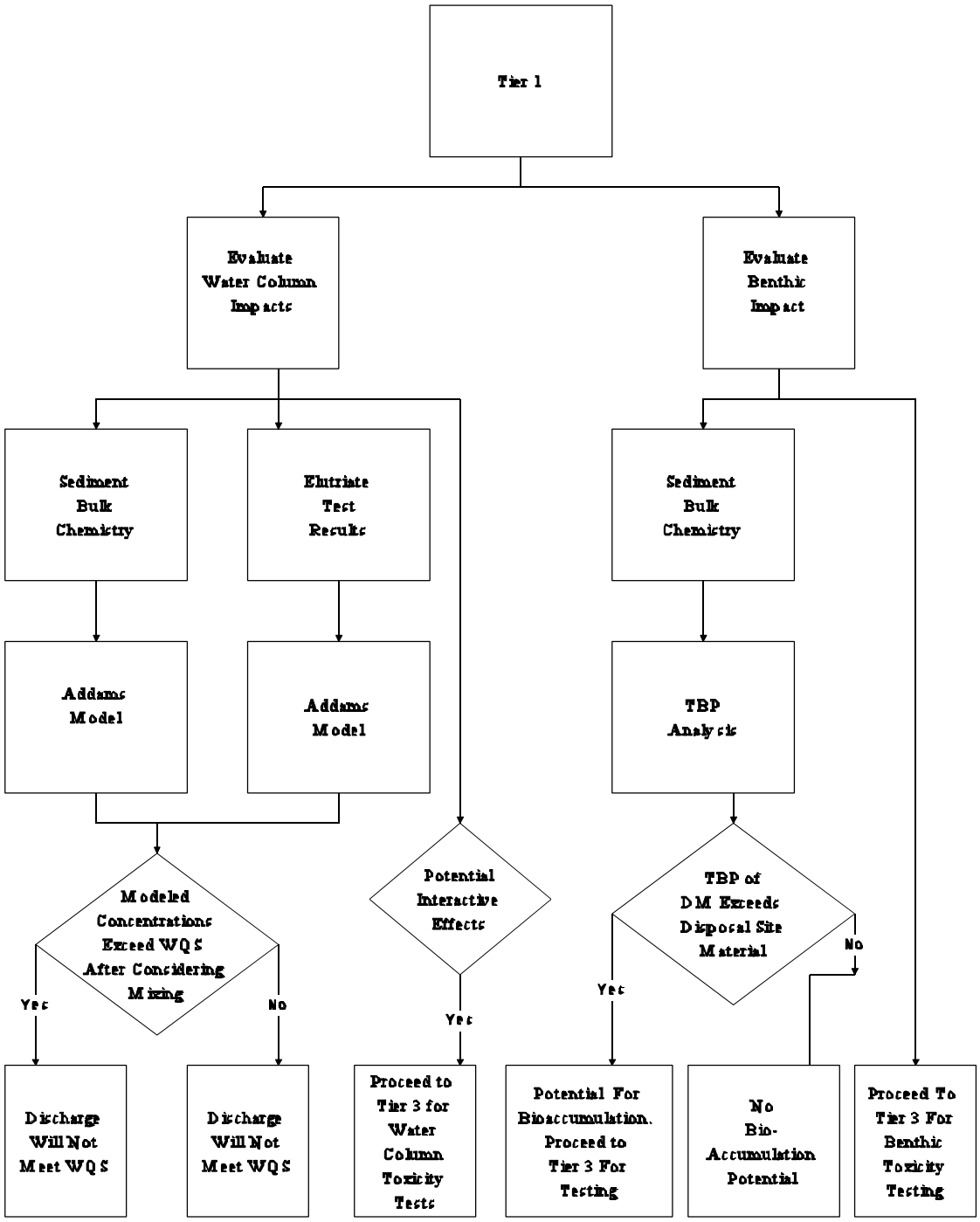

Figure 7. Tier 2 Flow Diagram

Because of the limitations in the ability to reach a decision at Tier 2, it is possible to go directly to Tier 3 testing to develop the information necessary for a contaminant determination. However, the cost of biological testing in Tier 3 will be a major constraint in the number of samples collected.

In order to keep these costs in line, while collecting samples that are representative, physical and chemical data of the type used in Tier 2 may also be needed to develop the framework for a sampling design in Tier 3. Guidance on the sampling design is provided in Appendix D.

Where practicable, it is recommended that a written plan for sediment sampling and analyses be prepared and provided to the appropriate Federal and State agencies for coordination prior to sampling. The Tier 1 evaluation would be a logical attachment to the sampling and analysis plan for agency review and comment. This coordination will reduce the chance of having to repeat costly procedures and assist in keeping projects on schedule.

4.3 Sediment Sampling and Analyses

4.3.1 Sampling Methods and Locations

Detailed guidance on acceptable sediment sampling methods and procedures is provided in Appendix D. Included in this appendix are information on acceptable sediment collection and handling procedures. Also included is guidance on how to plan and execute a sampling program. Sediment sampling plans are so site specific that guidance on the number, type, and location of samples is necessarily quite general.

A sediment sampling program for a 404(b)(1) evaluation should collect samples that are representative of the materials to be dredged, and the sediments at the disposal site. The sampling results will be used to determine if all or part of the dredged material for a proposed project are suitable for open water disposal. The historical information collected in Tier 1 should be used in the formulation of the sediment sampling program. This will focus resources on data gaps and minimize redundant data collection.

In any sampling program, a finite number of samples are used to represent some larger area or volume, possibly with some consideration of time. Factors that should be considered in selecting the number, type and locations of sediment samples include:

- distribution of sediments to be dredged,
- known or suspected contaminant distribution,
- dredging methods, and
- tests to be performed.

The distribution of dredged material may be known from bathymetric soundings or previous dredging records. The distribution of sediment contaminants can be estimated based on

historical data and/or information about contaminant sources and pathways developed in Tier 1. Within a single project, dredged material from different areas may have differing levels of contamination, and may have differing disposal requirements. Sampling plans for these dredging sites should be designed to accommodate irregular dredged material distributions, with a contaminant and/or volume bias. Grids and other statistically derived sampling plans are often not useful in these applications.

The approach used to collect representative samples of the dredged material may differ from that used to collect representative samples from the disposal site. The dredged material is a 3-dimensional mass of sediments to be excavated. The disposal site is a 2-dimensional area which will become covered by a new surface as the dredged material are discharged. Samples collected at the disposal site therefore need only represent the surficical sediments.

The dredging method should also be considered in the sampling design. It is impractical to define lateral or vertical distributions of sediment contamination that are beyond the precision of anticipated dredging equipment and operational constraints. For example, vertical sub-sampling at increments less than two feet is not recommended because of the limitations of dredging accuracy.

The types of analyses to be performed on the sediments are another factor in the sampling program. Some tests require large volumes of sample, which may limit sampling equipment selection. Finally, the costs of laboratory analysis is often an overriding practical consideration limiting the number of samples collected.

4.3.2 Disposal Site Sample Selection

Section 404(b)(1) Guidelines (1976) direct that contaminant determinations be made by comparing the dredged material to the sediments at the disposal site. For purposes of a dredged material discharge permit, the disposal site is typically defined by a "box" on a map, outlining an area where dredged material are to be placed by a barge, pipeline or other method. At a non-dispersive site, dredged material remain within the "box," typically forming a mound.

This concept of a "boxed" disposal site is limited in the Great Lakes, where the majority of dredged material disposal sites regulated under Section 404 are in shallow waters with highly dispersive currents and wave energies. In these conditions, dredged material do not form mounds, but are rapidly dispersed over areas several times as large as the original "box"

within days, weeks, or months. Because of the dispersive nature of most Great Lakes dredged material disposal sites, regional guidance is presented here for selecting the sediment for testing that best reflects the disposal site. This may include collection of samples that are physically outside the "box".

Disposal site sediment is taken from a location chosen to serve as the point of comparison for potential contaminant effects of the proposed dredged material. The sample should reflect the conditions at the disposal site, with the following considerations:

- physical similarity to dredged material;
- proximity to sources of contamination; and
- proximity to disposal site "box".

The selection of a disposal site sediment may be complicated where these considerations are conflicting.

Differences in grain sizes of sediments can affect organisms used in toxicity or bioaccumulation tests, and may confound the interpretation of contaminant effects. To the extent possible, the organisms recommended in this manual for Tier 3 benthic toxicity and bioaccumulation tests were selected because of their tolerance for a wide range of sediment physical properties. Nonetheless, the ideal disposal site sediment is physically similar to the dredged material so that the potential effects of grain size variations are minimized.

Where the dredged material and the sediments at the disposal site are physically dissimilar, it may be appropriate to consider nearby areas for a sediment sample that is more physically similar to the dredged material, while also reflecting the contaminant-related conditions at the disposal site. For example, many dispersive disposal sites have coarse grained sediment. If the dredged material are more fine-grained, it is likely they would not remain within the disposal site "box" for very long. Sediments from a nearby, less dispersive area, if available, might be more coarse grained and better match the particle size characteristics of the dredged material more closely. The fine grained dredged material are also more likely to have a higher residence time in such areas than within the dispersive "box".

The second consideration is intended to discourage the use of a disposal site sediment that has been contaminated to a substantial degree by sources other than dredged material. The selection of a disposal site sediment from areas of localized contamination, such as from spills or point discharges, in order to bias the dredged material evaluation is not acceptable.

However, few areas of the Great Lakes are without any contamination, and some large areas, particularly those near major tributaries, do have sediments with appreciable levels of background contamination. Background contamination that reflects the conditions of a large area, including the disposal site "box", is not an appropriate rationale for dismissing a disposal site sediment from use in the dredged material evaluation.

The last consideration of the disposal site sample selection is that the disposal site sediment be collected from within or as close as practicable to the disposal site "box". If the disposal site has never been used for dredged material disposal, the sample for comparison should, allowing for the other considerations, be collected from within the "box". If it is necessary to move outside the "box" to get a suitable sample, the distance should be kept to a minimum to best reflect the contaminant conditions of the disposal site. The maximum distance for a disposal site sample would be that which dredged material might be transported by normal currents or wave energies in 5-21 days (the duration of bioassay tests).

Beach nourishment, the placement of dredged material above the high water line, is a common disposal practice in the Great Lakes. The runoff of return water from such disposal operations to the adjacent lake or river is a 404 discharge. The water that receives this runoff is the disposal site, and the disposal site sediment selected from this site. However, dredged material that is suitable for beach nourishment typically meets the exclusions from testing.

Additional guidance on the selection of a disposal site sediment sample is provided in Appendix D. The rationale for sample site selection should be documented in the 404(b)(1) evaluation.

4.3.3 Physical and Chemical Analyses

Guidance on laboratory procedures for physical and chemical analysis of sediments is provided in Appendix F. Included in this appendix are acceptable procedures for laboratory analysis of the more common sediment contaminants on the Great Lakes. These procedures were determined to be suitable for achieving detection limits below ambient levels for these sediment contaminants. Any variation from these procedures should be coordinated with the USACE District and USEPA Region.

Also included in Appendix F are the accepted procedures for the preparation and chemical analysis of an elutriate. The elutriate test (USACE 1976) is a procedure developed to simulate the release of dissolved contaminants from a hydraulic dredged

disposal operation in open waters, and may be considered a worst case analysis for the release of dissolved contaminants from a mechanical dredged disposal operation. The elutriate test is used to evaluate water quality compliance for Section 401 certification (see paragraph 4.5.3). Elutriate concentrations should be reduced to reflect dilution resulting from mixing and dispersion at the proposed disposal site.

4.3.4 Quality Assurance

Quality assurance (QA) is a critical element within any 404(b)(1) contaminant evaluation. The importance of QA is not limited to the laboratory, but extends throughout the evaluation. General QA guidance and the data quality objectives (DQOs) for Great Lakes dredged material testing and evaluation is provided in Appendix E. More specific quality control (QC) guidance for dredged material sampling and handling is provided in Appendix D. Minimum QC requirements for analytical procedures are provided in Appendix F for chemical and physical analyses.

4.4 Benthic Impact Evaluations

One objective of the Tier 2 benthic evaluation is to determine if dredged material contaminants have the potential to cause an unacceptable adverse impact on benthic organisms, or on other aquatic organisms through bioaccumulation. This tier uses sediment chemical data with calculations and/or models to predict potential benthic and bioaccumulation impacts. The current state-of-the-art will allow only a partial resolution of this objective.

4.4.1 Potential for Bioaccumulation

Bioaccumulation is the uptake and retention of contaminants by organisms. In aquatic systems, sediment contaminants may bioaccumulate to levels having ecological and human health consequences. Some non-polar organic contaminants and a few metals have been found at elevated levels in the tissues of fish and other organisms, resulting in consumption advisories. Not all sediment contaminants will bioaccumulate. Some are readily metabolized, or degraded, within the organism's body. Others are simply not taken up. A listing of Great Lakes critical pollutants, many of which are bioaccumulative is provided in Appendix C.

The following factors should be considered to determine which (if any) contaminants should be evaluated for bioaccumulation potential:

- presence in the dredged material,
- propensity to bioaccumulate from sediments, and
- presence on applicable fish consumption advisories.

A list of potentially bioaccumulative contaminants should be a subset of the contaminants of concern list developed in Tier 1.

This manual provides a procedure to estimate the potential for bioaccumulation of certain sediment contaminants. Using this procedure, it is possible to determine if bioaccumulation testing is necessary in Tier 3.

4.4.1.1 Theoretical Bioaccumulation Potential (TBP)

TBP analysis was developed by McFarland (1984), based upon the laboratory work of Konemann and Van Leeuwen (1980) and Karickhoff (1981), and the results of later field studies. TBP utilizes the following equilibrium partitioning theory-based algorithm:

$$[\ TBP = pf\ (\ C_s\ /\ TOC\ )\ L\ ]$$

where:

pf = preference factor (a constant set to = 4.0)

C_s = the concentration of non-polar organic chemical in the dredged material or disposal site sediment, usually expressed as dry weight mg/kg (ppm)

TOC = total organic carbon content of the dredged material or disposal site sediment usually expressed as a dry weight decimal fraction (i.e., 2% = 0.02)

L = organism lipid content usually expressed as a decimal (wet weight fraction (i.e., 3% = 0.03)

TBP = wet weight of contaminant concentration in fish or organism tissue in mg/kg (ppm).

This algorithm uses the association between many non-polar organic contaminants and non-polar organic matrices in sediments and biota, known as equilibrium partitioning. In an idealized, closed system composed of sediment, organisms and water, the non-polar organic contaminants held by the sediment TOC will partition over time into the lipid compartment of organisms. At equilibrium, the non-polar organic contaminants will preferentially reside in the organism lipid. The preference factor setting at 4.0 is based upon the results of laboratory and field studies.

To perform a TBP evaluation, the evaluator must obtain data on the concentrations of non-polar organic contaminants and TOC in the proposed dredged material and disposal site material, as discussed in paragraph 4.4.1.1. The lipid content of the selected target organism(s) can be obtained from literature values or direct measurements. A listing of ranges of lipid content typically found in a variety of Great Lakes aquatic organisms is provided in Appendix C. Target organisms for TBP analysis may be selected because of their economic and/or ecological importance. Lipid levels of specific organisms (species) may vary widely with sex, age classes, size classes, and regional populations.

Using the above formula, and the data collected, the TBP may be calculated for every combination of sediment and target organism. For example, a sediment with 2 mg/Kg dry weight PCBs and 3% TOC has the potential to cause a fish with 6% lipid to have a PCB body burden of 16 mg/Kg wet weight.

TBP represents a theoretical condition of equilibrium, which is rarely present in the field. This condition is most closely met by organisms that have constant, direct contact with the sediment, such as a burrowing worm. The use of TBP to predict bioaccumulation from sediment in more mobile organisms, such as migratory fish, can be complicated by a number of factors. At this time, TBP should only be considered a worst-case estimate of potential bioaccumulation in fish.

The TBP for the proposed dredged material should be interpreted by comparison to the TBP of the disposal site material. If the TBP of the dredged material is not greater than that of the disposal site, no bioaccumulation testing for non-polar organic contaminants may be necessary. For any non-polar organic contaminant having a consumption advisory, the TBP for the appropriate species and size/age classes listed should be evaluated.

The TBP algorithm is not suitable for sediments with TOCs of less than 0.5%. If the dredged material or disposal site sediment contain less than 0.5% TOC, the potential for bioaccumulation should be presumed where the concentrations of hydrophobic contaminant(s) in the dredged material are greater than disposal site sediment. Under these circumstances, bioaccumulation testing in Tier 3 would be warranted. The necessity for bioaccumulation testing for other circumstances where TOC is less than 0.5% should be determined on a case-by-case basis.

4.4.1.2 Bioaccumulation Potential of Other Contaminants

Aside from the non-polar organic contaminants, only a limited number of other contaminants have been shown to bioaccumulate from sediments to aquatic organisms. For other bioaccumulative contaminants, there are no well established relationships between concentrations in sediment and organism tissues. The need for bioaccumulation testing for these contaminants may be determined based upon the comparison of the contaminant concentrations in the dredged material and disposal site sediment, taking into consideration any consumption advisories.

Future research may result in chemical relationships and predictive tools, similar to TBP, for other classes of sediment contaminants.

4.4.2 Benthic Toxicity

Procedures for predicting the toxicological response of benthic organisms to dredged material contaminants based on chemical data are not available. Potential applications of national sediment criteria are discussed in paragraph 4.6.

4.5 Water Column Impact Evaluations

Another objective of the Tier 2 evaluation is to determine if the dredged material contaminants will cause an unacceptable adverse impact on organisms within the water column and comply with applicable water quality standards, using chemical data. The state-of-the-art will allow only a partial resolution of water column biological impacts, but will provide sufficient information to address water quality compliance.

4.5.1 Water Quality Screening

There are two approaches used in Tier 2 to evaluate the potential impacts of a dredged material discharge on water quality. The first approach employs a water quality screening model to assess the conservative, worst-case water quality impacts of the proposed discharge. This model assumes 100 percent release of sediment-bound contamination into the water column, and calculates the concentrations of contaminants at the disposal site, allowing for mixing. The second approach utilizes the results of sediment elutriate analyses together with the mixing zone model.

If bulk chemical data representative of the proposed dredged material is available, it is recommended that the first approach be used. If the results with the screening model show that using

worst-case assumptions, the discharge would not exceed State water quality standards, no elutriate testing should be necessary. If the results of the screening model indicate the potential for exceeding State water quality standards, or if no bulk chemical data is available, the elutriate tests should be performed to determine compliance with State water quality standards.

The computer model used in Tier 2 for the evaluation of water quality is a part of a collection of computer models named Automated Dredging Disposal Alternatives Management System (ADDAMS). Floppy discs with the ADDAMS model, and full documentation are provided in the "Inland Testing Manual" (USEPA/USACE, 1998). The module of ADDAMS utilized in the Tier 2 analysis is STFATE (Short Term FATE). This module was developed for predicting the concentration of dredged material contaminants within a specified mixing zone. It can also determine the size of a mixing zone necessary to meet a specified standard. STFATE was developed for simulating disposal from a barge, scow or hopper in relatively deep water. Models for simulating disposal in shallow water (<15 feet) and beach nourishment are in development.

The impacts of a dredged or fill discharge are quite different from those of a permanent, wastewater point-source discharge. Dredged material discharges have not been regulated under the National Pollutant Discharge Elimination System (NPDES) of Section 402 of the Clean Water Act. For these reasons, the evaluation of a mixing zone for a dredged or fill material discharge is generally more complex, requiring consideration of additional factors beyond those used for NPDES mixing zone evaluations. The ADDAMS modules were developed for this more complex evaluation.

Part 230.11(f) of the Guidelines states that, "The mixing zone shall be confined to the smallest practicable zone within each specified disposal site that is consistent with the type of dispersion determined to be appropriate by the application of these Guidelines." The following factors should be considered in determining the acceptability of a proposed mixing zone:

. depth of water;
. current velocity, direction, and variability;
. degree of turbulence;
. stratification attributable to causes such as obstructions, salinity or density profiles;
. discharge vessel speed and direction, if appropriate;
. rate of discharge;
. ambient concentration of constituents of interest;
. dredged material characteristics, particularly

concentrations of constituents, amount of material, type of material (sand, silt, clay, etc.) and settling velocities;
- number of discharge actions per unit of time, and;
- other factors of the disposal site that effects the rates and patterns of mixing.

In order to run the model, the evaluator must obtain information about the disposal site necessary to address the above mixing zone factors, as well as data on the dredged material (bulk chemistry, solid content, void ratio, specific gravity). For the application with sediment bulk chemistry (step 1), the model need only be run for the contaminant of concern that requires the greatest amount of dilution to meet applicable State water quality standards. If this contaminant is shown by the model analysis to meet the State standards, all of the other contaminants would require less dilution and will also meet acceptable concentrations within the mixing zone.

If the application of the model with bulk chemical data shows potential exceedance of State water quality standards outside the mixing zone, the model should be rerun using elutriate data. If the results still exceed applicable standards outside the mixing zone, alternative disposal methods or management measures should be considered.

4.5.2 Water Column Toxicity

Procedures for predicting the toxicological response of water column organisms to dredged material contaminants based on sediment bulk chemical data are not available. Most applicable State water quality standards are derived from aquatic toxicity or human health data in conjunction with other factors. In some cases, State standards are specifically linked to aquatic toxicity tests. Water quality screening that demonstrates compliance with applicable water quality standards may therefore address water column toxicity concerns. However, the potential for interactive (i.e. synergistic, antagonistic) effects of contaminants on aquatic toxicity will necessitate that Tier 3 testing be conducted for most dredged material with more than a single contaminant of concern.

4.5.3 Section 401 Certification

Section 401 of the Clean Water Act requires that any applicant for a 404 permit must provide the permitting agency a certification from the State that the discharge complies with applicable State water quality standards. Part 230.10 (a)(5)(b) of the Guidelines states that, "No discharge of dredged or fill material shall be permitted if it: (1) Causes or contributes,

after consideration of disposal site dilution and dispersion, to violations of any applicable State quality standards".

Section 401 certification is wholly the responsibility of the States. Some States have codified specific testing procedures and requirements for making Section 401 certification determinations, but most have not. The testing and evaluation procedures presented in this manual address all aspects of water quality impacts from dredged material discharges, and should be sufficient for a Section 401 decision.

A letter requesting 401 certification, together with information and data demonstrating compliance with State water quality standards will be sent by the USACE District Engineer to the appropriate State agency at the earliest practicable time. The USACE Final Rule for Operation and Maintenance of Army Corps of Engineers Civil Works Projects Involving the Discharge of Dredged Material into Waters of the U.S. or Ocean Waters (33 CFR Parts 209, 335, 336, 337, and 338) provides timeframes for 401 certification. The USACE will assume the State has waived 401 certification if the State agency does not respond in a timely manner.

If the mixing zone determined in accordance with Part 230.11(f) of the Guidelines is substantially different from the mixing zone defined by the State 401 authority, the evaluator should reconcile the differences in coordination with the State, USACE and USEPA.

4.6 Contaminant Determination

After consideration of all available information, one of the following two possible **conclusions** can be reached at Tier 2:

1 - Existing information does not provide a sufficient basis for making a contaminant determination. In this case, further evaluation at Tier 3 is appropriate.

2 - Existing information does provide a basis for making a contaminant determination. In this case, one of the following two **determinations** can be reached:

a) The proposed dredged material discharge will not cause unsuitable, adverse, contaminant-related impacts.

b) The proposed dredged material discharge will cause unsuitable, adverse, contaminant-related impacts.

The current state-of-the-art will provide adequate information for a contaminant determination at the end of Tier 2

in only a limited number of situations. If the only cause for proceeding into Tier 2 was the presence of a single contaminant, of which the toxicology and bioaccumulation potential are well understood, a determination may be completed in Tier 2. In addition, if Tier 2 testing was performed solely for determining 401 compliance, a determination may be completed here.

When (and if) national sediment quality criteria (SQC) are developed, they may be applied in Tier 2. However, the application of numerical SQC would probably not address potential interactive effects of contaminants for which additional testing may be necessary.

4.7 Reporting

Information gathered under Tier 1 and Tier 2 must be summarized and condensed in the 404(b)(1) evaluation document. Because a comprehensive tiered evaluation will likely gather far more information than can be presented in the 404(b)(1) evaluation, and because of the importance of the decisions made at this tier, it is recommended that this information be documented and filed as a backup to the 404(b)(1) evaluation. This documentation should be developed into a report that can be distributed for State and Federal agency review and if necessary, inserted as an appendix to the 404(b)(1) evaluation public review document.

A summary of the results from Tier 2 analysis should include the following, along with the summary of results developed from the Tier 1 analysis discussed above in paragraph 3.7:

- sampling results of sediment bulk chemistry and physical testing program;
- QA/QC documentation;
- water column impact evaluations (where appropriate), including; water quality screen/model results, or elutriate/model results, mixing zone determination, and;
- benthic impact evaluations (where appropriate), including; list of potentially bioaccumulative contaminants, TBP calculation results, and evaluation of non-hydrophobic, bioaccumulative contaminants.

5. TIER 3 - BIOLOGICAL TESTING

5.1 Purpose

The purpose of Tier 3 is to make contaminant determinations through the use of effects-based biological tests (figure 8). It is anticipated that the vast majority of contaminant

determinations will be reached at Tier 1 or Tier 3. As outlined in Tier 1, dredged material which are not a carrier of contaminants, which satisfy the exclusions from testing, or which have sufficient historical data will require no additional testing for a determination.

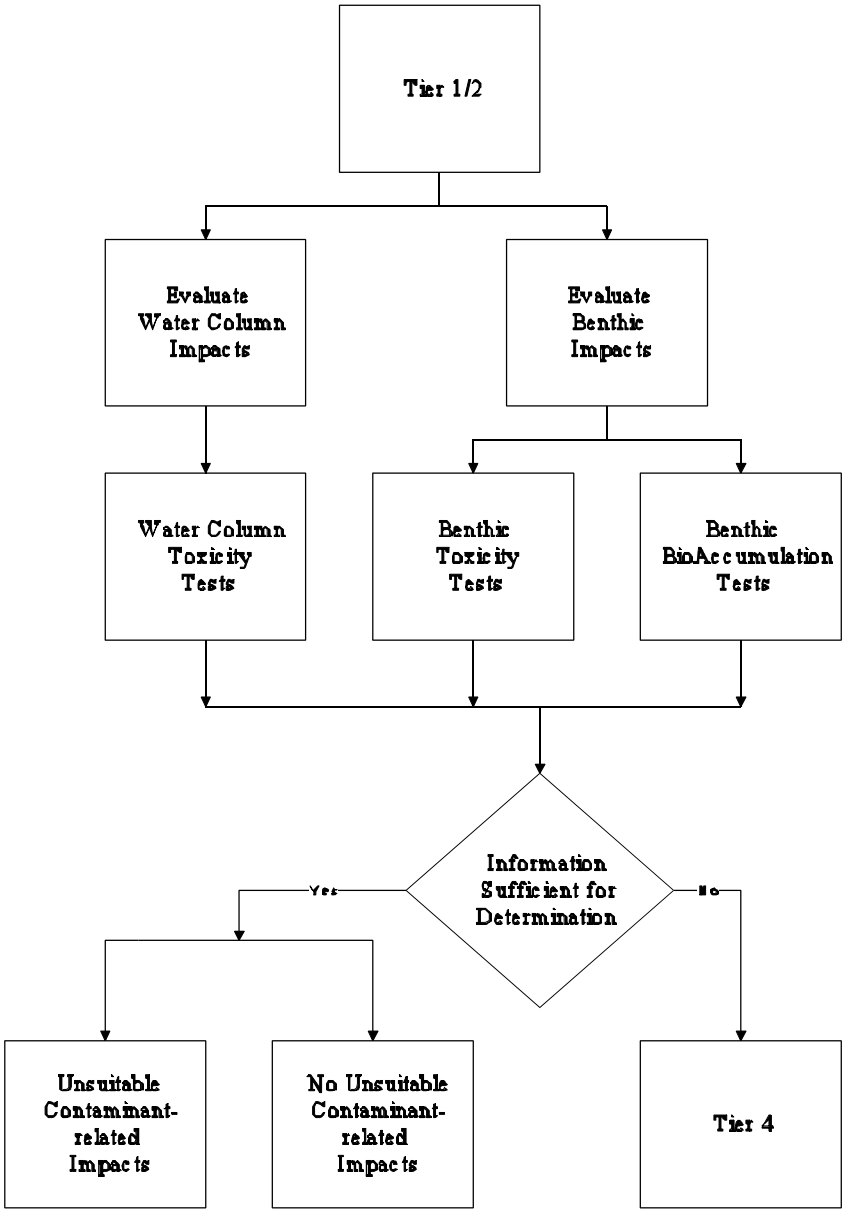

Figure 8. Tier 3 Flow Diagram

In Tier 2, it was intended that a determination be made using sediment physical and chemical data alone. However, there are relatively few biological effects that can be correlated with

specific contaminants in sediments. In addition, sediments typically contain complex mixtures of contaminants and the interactive effects of these contaminants on biological organisms cannot yet be predicted based upon physical and chemical data alone. As a result, there are very few situations where a determination can be reached in Tier 2.

Appendix G presents six effects-based biological tests for dredged material evaluation. Potential water column and benthic impacts of the discharge of dredged material are evaluated through Tier 3 biological tests. It is expected that the completion of these tests will result in information sufficient for making a contaminant determination. Only in unusual cases should further testing in Tier 4 testing be necessary.

5.2 Planning and Coordination

Planning and coordination is needed in all stages of a 404(b)(1) evaluation, but the need is especially critical in Tier 3 because of the high costs of biological effects testing. For most dredging projects, these high costs will necessitate that each sample represent a larger portion (e.g., management unit) of the area to be dredged. Coordination with other agencies conducted in earlier tiers should be continued in Tier 3. A written plan for sediment sampling and analyses should be prepared and provided to the appropriate Federal and State agencies for coordination prior to sampling.

5.3 Sediment Sampling and Analysis

5.3.1 Sediment Sampling

Detailed guidance on acceptable sediment sampling methods and procedures is provided in Appendix D. Included in this appendix are information on acceptable sediment collection and handling procedures. Also included is guidance on how to plan and execute a sampling program. Sediment sampling plans are so site specific that guidance on the number, type, and location of samples is necessarily quite general. The guidance provided in paragraph 4.3 is generally applicable to Tier 3 sampling.

Because of the limitations of Tier 2 in reaching a contaminant determination without further testing, the evaluator may decide to collect data for Tier 2 and Tier 3 at the same time. This may be appropriate where Tier 1 has yielded an extensive amount of information about the physical and chemical properties of the dredged material and their distribution. If there is very limited information about the physical and chemical nature of the dredged material, it is recommended that a Tier 2 evaluation be completed before proceeding with Tier 3 sampling.

Because of the cost of effects-based testing and the volume of dredged material sample needed for a suite of tests, the total number of samples tested in Tier 3 will generally be much fewer than in Tier 2. As a result, the dredging site must be divided into subareas, or "management units". The test results from a single sample (or composite) are used to make a determination about the contaminants in each management unit.

It is possible to have different results for different samples from a single dredging project. The management unit concept was developed for this condition. The contaminant determination for a single dredging project composed of several management units may be that one area is acceptable for open water disposal, another area is unacceptable, and a third has an inconclusive determination after Tier 3.

The delineation of management units for a proposed dredging project is an important step, and should be made through consideration of:

- information from Tier 1 evaluation,
- data from Tier 2 testing (if available), and
- proposed dredging and disposal method.

While the linkages between physical/chemical characteristics of sediments and biological effects are not well understood, the physical and chemical homogeneity of dredged material in a specific area of a river or harbor is considered appropriate rationale for management unit delineation. The sediments within a management unit will typically be dredged and disposed within a limited timeframe, mixed and homogenized to some degree during handling, and will likely be disposed in the same portion of the disposal site.

5.3.2 Effects-Based Tests

Effects-based biological tests are laboratory procedures in which organisms are exposed to a contaminated medium. Most of the water quality standards and criteria for specific contaminants were developed from effects-based tests. These types of tests used direct exposures of organisms to known levels of a single contaminant. Example of test exposures include a mouse fed a contaminant in its food, or a fish placed in a tank with the contaminant dissolved in its water. The biological effects which may be measured by such tests include mortality (death) of the organism, growth, reproduction, and others.

A number of methodologies for the bioassessment of freshwater sediments have been developed (Dillon and Gibson, 1990; Dillon and Gibson, 1986). Some of the existing

methodologies were developed to measure biological effects related to specific contaminants. Some were designed to simulate specific exposure conditions. Most are tests intended to measure the response of a sensitive organism to a mixture of sediment contaminants.

The type of organism, exposure media, exposure conditions, and measured effects or end-points are all specific to the questions being addressed. In the context of a 404(b)(1) evaluation, the question being asked is not what impacts the sediment contaminants are having in-place, but what impacts they would have if the sediments were dredged and discharged somewhere else.

Biological-effects tests for dredged material testing and evaluation must represent the physical and chemical conditions of contaminant exposure during dredged material disposal. For a 404(b)(1) evaluation, there are two exposure conditions to be tested; water column and benthic. The water column exposure is directed at the impacts of contaminants released into the water from dredged material as they are discharged and settle to the bottom. The benthic exposure is directed at the impacts of contaminants in the dredged material after they have deposited on the bottom at the disposal site.

For this manual, the USEPA and USACE have developed six effects-based biological tests for dredged material evaluation. Three of the tests developed for this manual are water column tests, which utilize sediment elutriate preparations. The other three are benthic tests, which utilize whole sediment as test media. Complete methodologies for the six tests are provided in Appendix G. The six biotests are summarized on table 2.

These six test organisms were selected for a number of reasons. All are easily cultured and handled in a laboratory setting, and are relevant from an ecological standpoint. The three species for the water column (elutriate) tests (*Daphnia magna*, *Ceriodaphnia dubia* (which are both cladocerans), and *Pimephales promelas* (fathead minnow) have been used extensively in the NPDES permitting program. These three species are relatively sensitive to a variety of contaminants, and standard test methods are available for both short-term and long-term exposures with these organisms (USEPA 1989, 1991). With a few modifications, these methods have been adapted for dredged material elutriate testing (Appendix G).

The midge *Chironomus tentans* and the amphipod *Hyalella azteca* are used to estimate the toxicity of solid phase dredged material. Both species have been widely used for sediment assessments, and standard test methods developed (ASTM 1992,

Ankley et al. 1993). We recommend that both species be tested in routine dredged material assessments, as they vary in their sensitivity to different contaminants, e.g., *H. azteca* is quite sensitive to metals, while *C. tentans* tends to be more sensitive to pesticides.

Table 2. Effects-based biological tests

Species	Test Type[1]	Endpoint(s)	Test Duration (days)[2]
Daphnia magna	E	Survival/Survival and reproduction	2/21
Ceriodaphnia dubia	E	Survival/Survival and Reproduction	2/7
Pimephales promelas	E	Survival/Survival and Growth	4/7
Chironomus tentans	S	Survival and Growth	10
Hyalella azteca	S	Survival and Growth	10
Lumbriculus variegatus	S	Bioaccumulation	28

[1] Elutriate (E) or solid phase (S)
[2] Only short-term tests recommended for Tier 3 application.

The oligochaete *Lumbriculus variegatus* is used to assess the potential bioaccumulation of contaminants from dredged material. Unlike many other freshwater macroinvertebrates that have been used for sediment tests, *L. variegatus* is large enough to ensure that adequate tissue mass is available to perform chemical analysis for bioaccumulative contaminants. Standard methods have been developed for testing *L. variegatus* (Phipps et al. 1993), and the test has performed well in field validation studies (Ankley et al. 1992).

While there are many other biological tests which have been developed for sediments, only those presented in this manual are recommended for Tier 3 evaluation at the present time. Other tests, which are not considered ready for regional use in 404(b)(1) evaluations are discussed briefly in Tier 4. The USEPA and USACE will continue to consider other effects-based tests for their applicability to Great Lakes 404(b)(1) evaluations. Future updates of this manual may include modifications to the test procedures presented here and new tests for inclusion in Tier 3.

5.3.3 Quality Assurance

Quality assurance is a critical element in all tiers of a 404(b)(1) contaminant evaluation. General QA guidance and the

data quality objectives for Great Lakes dredged material testing and evaluation is provided in Appendix E. Quality control guidance for dredged material sampling and handling is provided in Appendix D. Minimum QC requirements for the performance of specific effects-based tests are provided in Appendix G.

5.4 Benthic Impact Evaluations

The Tier 3 benthic evaluation will determine if dredged material contaminants have the potential to cause an unacceptable adverse impact on benthic organisms. Two toxicity tests and one bioaccumulation test have been developed for regional use in this manual.

5.4.1 Benthic Toxicity Tests

The methodologies for the benthic toxicity tests with *Chironomus tentans* and *Hyalella azteca* are detailed in Appendix G. *Chironomus tentans* is the insect known as the midge fly. Midge fly larvae are often referred to as "bloodworms" because of the hemoglobin pigment in their bodies gives them a distinctive red coloration. This species is a non-biting form whose larvae are typically found burrowing in sediments of eutrophic ponds and lakes, and is an important food item in the diets of bottom feeding fish.

H. azteca is an amphipod (also called a scud or sideswimmer) which is a small freshwater crustacean which inhabits the water column and sediment surface, feeding on detritus. This species is an important food item for bottom feeding and water column fish in the Great Lakes.

The benthic toxicity tests are conducted by placing the test organisms into small (300 ml) beakers which are filled with water and have a layer of the test sediment at the bottom. The water overlying the sediment is renewed periodically. Organisms are fed during the exposure. The tests are completed in ten days, at which time the organisms are examined for response.

Both of these toxicity tests have been developed to measure lethal or sublethal responses. The lethal response is measured as mortality or survival of organisms. The sublethal response measured is growth. The results of these toxicity tests for the dredged material and the disposal site sediment are compared statistically for the contaminant determination.

The USEPA and USACE recommend that both of these toxicity tests be used within Tier 3 for 404(b)(1) evaluations of Great Lakes dredged material and measured for survival. The USEPA and USACE recommend that growth be measured for Tier 3 evaluations

only for *C. tentans.* Interpretation guidance on sublethal responses for *H. azteca* is currently under development. When this guidance has been completed and accepted by the USEPA and USACE, it will be incorporated into the Tier 3 evaluation.

The results of the benthic toxicity tests must first be evaluated in light of the QA objectives defined in Appendix E. If the responses of organisms in control exposures are within acceptable limits, the test results with the dredged material and the disposal site sediment may be evaluated using the statistical methods described in the Inland Testing Manual (USEPA/USACE 1994).

Dredged material is considered **not** to meet the Guidelines when the mortality of test organisms exposed to the dredged material is more than 10 percent greater (20 percent for *C. tentans*) than the mortality of test organisms exposed to the disposal site sediment **and** is statistically different at the 95 percent confidence level.

Dredged material is considered **not** to meet the Guidelines when the mean weight of *C. tentans* exposed to the dredged material is less 0.6 mg per organism (dry weight), **and** the mean weight of organisms exposed to the dredged material is more than 10 percent less than the mean weight of organisms exposed to the disposal site sediment, **and** this difference in mean weights is statistically significant at the 95 percent confidence level.

Determinations based on survival of *C. tentans* and *H. azteca* and growth of *C. tentans* are considered independently. If the results of any of these three evaluations are negative, the dredged material discharge is considered not to meet the Guidelines. If negative test results are suspected to be the result of non-contaminant impacts, additional benthic toxicity testing using sublethal end points or other organisms may be considered in Tier 4.

5.4.2 Bioaccumulation Test

The methodology for the benthic bioaccumulation test with *Lumbriculus variegatus* is detailed in Appendix G. *L. variegatus* is a freshwater oligochaete worm (aquatic earthworm) that is 1-1.5 mm in diameter and 40-90 mm long. It burrows in sediments, is an important food item for bottom feeding fish, and is commonly cultured and harvested for fish food in pet stores.

The benthic bioaccumulation test is conducted by placing a large number (500-1000) of organisms into a 5.5 liter aquarium with a layer of sediment and overlying water. The water is

renewed periodically, but the organisms are not fed during the exposure (other than organic matter already in the sediments). The tests are completed in 10-28 days, at which time the organisms are prepared for chemical analysis.

Benthic bioaccumulation testing is **not** necessary if the proposed dredged material has no bioaccumulative contaminants of concern (as determined in Tier 1) or if the TBP analysis conducted in Tier 2 conclusively indicates that there is no potential for bioaccumulation of contaminants relative to the disposal site sediment.

If the contaminant of concern list for the dredged material includes bioaccumulative contaminants, and if analysis for potential bioaccumulation conducted in Tier 2 was inconclusive, the dredged material should be tested using the benthic bioaccumulation test. The results of bioaccumulation tests with the dredged material are compared statistically to the results with the disposal site sediment.

Dredged material is considered **not** to meet the Guidelines when the mean concentration of bioaccumulative contaminant(s) in test organisms exposed to the dredged material is statistically greater than the concentration of these contaminant(s) in test organisms exposed to the disposal site sediment.

5.5 Water Column Impact Evaluations

The Tier 3 evaluation will determine if the dredged material contaminants cause an unacceptable adverse impact on organisms within the water column. Three water column toxicity tests (elutriate-based tests) have been developed for this manual.

The methodologies for the water column toxicity tests with *Daphnia magna*, *Ceriodaphnia dubia*, and *Pimephales promelas* are detailed in Appendix G. *D. magna*, commonly called a water flea, is a freshwater cladoceran common in Great Lakes plankton. It, and its smaller cousin *C. dubia* have been cultured in the laboratory and used in a variety of bioassays. The daphnids are an important food item of small and young fish.

P. promelas is also called the fathead minnow. It is a small fish (about 10-14 cm at maturity) which is commonly used for fishing bait. It is a prolific breeder, has been used for toxicity testing both as an adult and as larvae. The fathead minnow is ubiquitous throughout the Great Lakes and its tributaries, and is a forage food for larger fish.

All three water column toxicity tests use elutriate preparations prepared by mixing sediment and water (on a 1:4

ratio) into a slurry. The slurry is allowed to settle and the supernatant decanted. The supernatant is then centrifuged to remove suspended particles. This supernatant is the elutriate, which is diluted in series and used as the test solution for water column toxicity tests.

The test organisms are exposed to the elutriate in beakers or small aquaria. The elutriate is renewed periodically and the organisms are fed during the exposure. The elutriate tests were developed to measure lethal and sub-lethal responses, with short- and long-term exposures. The *D. magna* tests are completed in two (short-term) or 21 (long-term) days. The *C. dubia* tests are run in two or seven days, and the *P. promelas* test in seven or 21 days. The lethal response is measured as mortality or survival of organisms. The sublethal response measured is reproduction for *D. magna* and *C. dubia* and growth for *P. pimephales*. The results of these toxicity tests for the dredged material are evaluated to determine if an unacceptable toxicity risk will occur outside the mixing zone. Water column testing of the disposal site sediment is not appropriate.

The water column tests simulate exposure conditions that may be very transient in the field. The majority of open-water disposal of dredged material in the Great Lakes occurs from barges, scows and hoppers which "dump" the material through bottom doors. These discharges are instantaneous, rather than continuous, and the time between discharges may be as short as 30 minutes to as long as several hours. The water column exposure period is limited to the time required for the dredged material to settle to the bottom (a matter of minutes or seconds). The discharge from a hydraulic dredge is more continuous, and can produce water column exposures more closely resembling the toxicity tests. However, hydraulic discharge is not commonly used in the Great Lakes except for beach nourishment disposal of dredged material.

Experience with effects-based testing of dredged material conducted for ocean disposal (Section 103) regulation has demonstrated that the benthic impacts of dredged material contaminants are more ecologically significant than water column impacts. Water column toxicity testing has been greatly reduced or eliminated in some regional 103 testing manuals.

For the above reasons, the USEPA and USACE recommend that only one of the water column toxicity tests be used within Tier 3 for 404(b)(1) evaluations of Great Lakes dredged material and measured for lethal responses with a short-term exposure. Interpretation guidance on sublethal responses for these tests is currently under development. When this guidance has been

completed and accepted by the USEPA and USACE, it may be incorporated into the Tier 3 evaluation.

One potential cost-saving measure during the implementation of water column tests that might be considered is to perform the test only with the full-strength elutriate, and not conduct the dilution series. Experience with similar tests and marine sediments has shown that undiluted elutriates infrequently produced mortality greater than 50 percent. While it must be recognized that there is a risk of having to repeat the test, the potential cost-savings outweigh this risk in most cases.

The results of the water column toxicity test must first be evaluated in light of the QA objectives defined in Appendix E. If the responses of organisms in control exposures are within acceptable limits, the test results with the dredged material may be evaluated using the statistical methods in the "Inland Testing Manual" (USEPA/USACE 1998) and the water quality screen model employed in Tier 2.

Dredged material is considered **not** to meet the Guidelines when the concentration of dredged material contaminants at the boundary of the mixing zone statistically exceeds 0.01 of the concentration (LC_{50}) causing 50 percent mortality of test organisms exposed to the dredged material elutriate. The screening model (paragraph 4.5.1) is used to calculate the dilution of the elutriate within the mixing zone.

5.6 Contaminant Determination

After consideration of all available information, one of the following two possible **conclusions** can be reached at Tier 3:

1 - Existing information does not provide a sufficient basis for making a contaminant determination. In this case, further evaluation at Tier 4 may be appropriate.

2 - Existing information does provide a basis for making a contaminant determination. In this case, one of the following **determinations** can be reached:

a) The proposed dredged material discharge will not cause unsuitable, adverse, contaminant-related impacts.

b) The proposed dredged material discharge will cause unsuitable, adverse, contaminant-related impacts.

The information obtained in Tier 3 and earlier tiers should be sufficient to reach a contaminant determination in almost all cases. Therefore, the first conclusion (information not

sufficient) should be reached only in unusual circumstances.

5.7 Reporting

Information gathered during Tiers 1, 2 and 3 must be summarized and condensed in the 404(b)(1) evaluation document. Because a comprehensive tiered evaluation will likely gather far more information than can be presented in the 404(b)(1) evaluation, and because of the importance of the decisions made at this tier, it is recommended that this information be documented and filed as a backup to the 404(b)(1) evaluation. This documentation should be developed into a report that can be distributed for State and Federal agency review and if necessary, inserted as an appendix to the 404(b)(1) evaluation public review document.

6. TIER 4 - CASE-SPECIFIC TESTING

6.1 Purpose

The purpose of Tier 4 is to make contaminant determinations through the use of case-specific testing and evaluation. It is anticipated that the information obtained from testing and evaluations in Tiers 1, 2 and 3 will not be sufficient for a contaminant determination in very few cases. For example, Tier 4 testing may be appropriate where Tier 3 test results are conflicting or inconclusive.

In these rare cases, testing procedures that have not been adopted for regional application, and those that are more research-oriented may be employed, as necessary. Because any testing and evaluation conducted in Tier 4 is entirely case-specific, limited guidance can be offered. Further, it must be recognized that Tier 4 is not an invitation to conduct basic research, but a mechanism for obtaining the information necessary to address case-specific dredged material contaminant impacts.

Tier 4 testing should be focused on contaminant issues not resolved in earlier tiers. If Tier 3 testing for water column toxicity and benthic bioaccumulation were conclusive but the benthic toxicity testing was not, Tier 4 testing should be limited to the unresolved benthic toxicity impacts of dredged material contaminants. Similarly, if Tier 3 testing produced conclusive determinations for some management units of a proposed dredging area, but not others, Tier 4 evaluations should be limited to those management units in question.

6.2 Planning and Coordination

Because there are no hard-and-fast rules in Tier 4, it is imperative that the testing and evaluation be coordinated with other agencies up front. When using testing procedures which have no established interpretive guidance, case-specific evaluative criteria must be developed in advance.

6.3 Testing and Evaluation Procedures

The tools that are used in Tier 4 to evaluate dredged material contaminant impacts may include toxicity and bioaccumulation tests which differ from the Tier 3 tests in both the level of intensity and in cost. Examples of these differences include:

- different end points,
- different test species, and
- varying exposure conditions to reflect case-specific field conditions.

The USEPA and USACE have developed methodologies for the sub-lethal benthic toxicity tests with *Chironomus tentans* and *Hyalella azteca* and sub-lethal water column toxicity tests with *Daphnia magna*, *Ceriodaphnia dubia*, and *Pimephales promelas*. These tests are developed for measurement of growth as a sublethal response, and the procedures are provided in Appendix G. Since the interpretation guidance for these tests has not been completed and accepted by the USEPA and USACE, the use of these sub-lethal toxicity tests remains an option under Tier 4 When the interpretation guidance is completed, these sub-lethal toxicity tests may be incorporated into the Tier 3 evaluation.

The "Inland Testing Manual" (USEPA/USACE 1998) lists a number of organisms for which toxicity and bioaccumulation tests have been developed. Although few of these tests were developed or used for regulatory decision making, this list can be used to identify potential species for Tier 4 testing.

Tier 4 may also require tools to evaluate the exposure and impacts of dredged material contaminants in the field, away from the disposal site, or on higher trophic levels. Examples of these tools include:

- field biota collection,
- field exposures (caged organisms),
- contaminant transport/contaminant fate modeling, and
- human health/ecological risk analysis.

When planning a Tier 4 evaluation, it is recommended that the evaluator review the Guidelines and keep the following principles in mind throughout:

- a benthic evaluation is made of contaminant impacts relative to the disposal site sediment,
- a water column evaluation must consider the effects of mixing, and
- a contaminant determination is directed at whether or not an impact will occur, and not why.

6.4 Contaminant Determination

At the conclusion of Tier 4, there are two possible **determinations** which can be reached:

a) The proposed dredged material discharge will not cause unsuitable, adverse, contaminant-related impacts.

b) The proposed dredged material discharge will cause unsuitable, adverse, contaminant-related impacts.

Dredged material management considerations, treatment options, or other actions which might be used to abate contaminant-related impacts are outside of the scope of this guidance manual.

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APPENDIX A
LIST OF ACRONYMS AND ABBREVIATIONS

ADDAMS - Automated Dredging Disposal Alternatives Management System
AOC - Area of Concern
ASTM - American Society of Testing and Materials

CDF - Confined Disposal Facility
CFR - Code of Federal Regulations
CWA - Clean Water Act

DMRP - Dredged Material Research Program
DNR - Department of Natural Resources
DO - dissolved oxygen
DQI - Data Quality Indicator
DQO - Data Quality Objective

EA - Environmental Assessment
EIS - Environmental Impact Statement
ER - Engineering Regulation

FDA - Food and Drug Administration
FONSI - Finding Of No Significant Impact
FY - Fiscal Year

GC - Gas Chromatography
GIS - Geographic Information Systems
GLTEM - Great Lakes Testing & Evaluation Manual

HTW - Hazardous and Toxic Wastes
HQUSACE - Headquarters, U.S. Army Corps of Engineers

IJC - International Joint Commission

Kg - Kilogram

LC_{50} - lethal concentration (50% mortality)

mg - milligram
MPRSA - Marine Protection, Research and Sanctuary Act
MS/MSD - Matrix Spike/Matrix Spike Duplicate

NEPA - National Environmental Policy Act
NOAA - National Oceanic and Atmospheric Administration
NPDES - National Pollutant Discharge Elimination System

PAH - Polynuclear Aromatic Hydrocarbon
PCB - Polychlorinated Biphenyl
PCS - Permit Compliance System
PL - Public Law
ppm - parts per million

QA - Quality Assurance
QAMP - Quality Assurance Management Plan
QAPP - Quality Assurance Project Plan
QC - Quality Control

RAP - Remedial Action Plan
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System

SOP - Standard Operating Procedure
SQC - Sediment Quality Criteria
STFATE - Short Term Fate
STORET - STOrage and RETrieval system

TBP - Theoretical Bioaccumulation Potential
TKN - Total Kjeldahl Nitrogen
TOC - Total Organic Carbon
TPH - Total Petroleum Hydrocarbons
TRI - Toxic chemical Release Inventory
TSCA - Toxic Substances Control Act
TVS - Total Volatile Solids

USACE - U.S. Army Corps of Engineers (Corps)
USEPA - U.S. Environmental Protection Agency (EPA)
USFWS - U.S. Fish & Wildlife Service
USGS - U.S. Geological Survey

VOC - Volatile Organic Compound

WES - Waterways Experiment Station
WQS - Water Quality Standards

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APPENDIX B
GLOSSARY OF TERMS

Absorbance: A measure of the decrease in incident light passing through a sample into the detector.

Accuracy: The closeness of agreement between an observed value and an accepted reference value. When applied to a set of observed values, accuracy will be a combination of a random component (precision) and of a common systematic error (or bias) component.

Action level: Criteria for taking action for the environmental variables or characteristics being measured.

Acute toxicity: Short-term toxicity to organism(s) that have been affected by the properties of a substance, such as contaminated sediment.

Adjacent: Bordering, contiguous or neighboring.

Aliquot: Measured portion of a field sample taken for analysis.

Analyte: Specific component measured in a chemical analysis.

Analytical sample: Any solution or media introduced into an instrument on which an analysis is performed excluding instrument calibration, initial calibration verification, initial calibration blank, continuing calibration verification and continuing calibration blank.

Assessment: Evaluation process used to measure the performance or effectiveness of a system and its elements.

Audit: Planned and documented investigative evaluation of an item or process to determine the adequacy and effectiveness as well as compliance with established procedures, instructions, drawings, QAPPs, and or other applicable documents.

Batch: A group of samples which behave similarly with respect to the sampling or the testing procedures and which are processed as a unit.

Bioaccumulation: The accumulation of contaminants in the tissue of organisms.

Bioaccumulation factor: The degree to which an organism accumulates a chemical compared to the source. A dimensionless factor derived by dividing the concentration in the organisms by that in the source.

Bioassay: A test using a biological system, involving the exposure of an organism to a test material and determining a response.

Bioavailable: Can be taken up by organisms (i.e., from water, sediment, food, etc.).

Blanks: Field and laboratory quality control samples that are processed with the samples.

Calibration: Systematic determination of the quantitative, linearity and dynamic range of response of a test to the concentration of the analyte of interest.

Certified reference material: A reference material whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate of other documentation which is issued by a certifying body.

Chromatography: A process of selectively separating a mixture into its component compounds.

Chronic (sub-lethal) toxicity: Biological tests which use such factors as abnormal development, growth and reproduction, rather than solely lethality, as end-points.

Coefficient of variation: Standard deviation as a percent of the arithmetic mean.

Comparability: Reflects the confidence with which one data set can be compared with others.

Completeness: Measure of the amount of valid data obtained as compared to the amount of data intended to be collected.

Contaminant: A chemical or biological substance in a form that can be incorporated into, onto or be ingested by and harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment, and includes but is not limited to the substances on the 307(a)(1) list of toxic pollutants promulgated on January 31, 1978 (43 CFR 4109).

Control limit: Range within which specified measurement results must be within to be compliant/valid.

Control sediment: A sediment essentially free of contaminants and compatible with the biological needs of the test organisms such that it has no discernable influence on the response being measured in the test. Control sediment may be the sediment from

which the test organisms are collected or a laboratory sediment, providing the organisms meet control standards.

Corrective action: Measures taken to rectify conditions adverse to quality and, where necessary, to preclude their recurrence.

Correlation coefficient: Number (r) which indicates the degree of dependence between two variables (e.g. concentration and response).

Data quality indicators: Measurable attributes of the attainment of the necessary quality for a particular environmental decision, including precision, bias, completeness, representativeness, reproducibility, comparability, and statistical confidence.

Data quality objectives: Qualitative and quantitative statements of the overall uncertainty that a decision make is willing to accept in results or decisions derived from environmental data.

Data validation: Process of evaluating available data against project DQIs and DQOs to make sure that the objectives were met.

Detector: Device used in conjunction with an analytical instrument to measure, and sometimes identify, the components of a sample.

Digestion: Process used prior to analysis that breaks down samples using acids (or bases). The end product is called a digestate.

Discharges of dredged material: Any addition of dredged material into waters of the United States and includes discharges of water from dredged material disposal operations including beach nourishment, upland, or confined disposal which return to waters of the United States. Material resuspended during normal dredging operations is considered "de minimis" and is not regulated under Section 404 as a dredged material discharge.

Disposal site: That portion of the United States waters where specific disposal activities are proposed or permitted. It consists of a bottom surface area and all overlying water, if present. Given that most disposal sites within the Great Lakes may be dispersive in nature, professional judgment may be necessary in the collection of sample(s) representing the disposal site (see discussion in section 4.3.3).

District: A USACE administrative area.

Dredged material: Material that is excavated or dredged from waters of the United States.

EC_{50}: The median effective concentration. The concentration of a substance that causes a specific effect in 50% of the organisms tested.

Elutriate: A suspension prepared by mixing specific volumes of sediment and water, used for chemical analysis and toxicity testing.

Estimated quantitation limit: Lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Evaluation: A process of judging data in order to reach a decision.

Extraction: A chemical or mechanical procedure to remove organic compounds from a sample matrix. The end product of extraction is called an extract.

Factual determination: A determination in writing of the potential short-term and long-term effects of a proposed discharge of dredged or fill material on the physical, chemical and biological components of the aquatic environment in light of Subparts C-F of the Guidelines.

Federal standard: The dredged material disposal alternative(s) identified by the USACE that represent the least costly, environmentally acceptable alternative(s) consistent with sound engineering practices and which meet the environmental standards established by the 404(b)(1) evaluation process.

Fill material: Any material used for the primary purpose of replacing an aquatic area with dry land or changing the bottom elevation of a water bottom for any purpose. The term does not include any pollutant discharge into the water primarily to dispose of waste, as that activity is regulated under Section 402 of the Clean Water Act.

Great Lakes and **Great Lakes Basin:** The United States waters of Lakes Michigan, Superior, Huron, Erie, Ontario, the connecting channels, St. Lawrence River, their tributaries and any other waterbodies within the United States watersheds of these Lakes.

Guidance: National or regional implementation manuals developed to assist the evaluator in making a contaminant determination as defined in 404(b)(1) Guidelines.

Guidelines: The Section 404(b)(1) final rule (40 CFR 230) dated December 24, 1980.

Holding time: Elapsed time expressed in days from the time of collection until the date of its processing and/or analysis.

Instrument detection limit: Smallest signal above background noise that an instrument can detect reliably.

LC_{50}: The median lethal concentration. The concentration of a substance that kills 50% of the organisms tested.

Limit of detection: Lowest concentration that can be determined to be statistically different from a blank.

Limit of quantitation: Level above which quantitative results may be obtained with a specified degree of confidence.

Management unit: A manageable, dredgeable unit of sediment which can be differentiated by sampling and which can be separately dredged from a larger dredging area.

Matrix: Component or substrate (e.g. water, sediment, tissue) which contains the contaminants or constituents of interest. Matrix refers to the physical structure of a sample and how contaminants are bound within this structure.

Matrix duplicate: A type of laboratory duplicate used for organic analyses.

Matrix effect: Physical or chemical interactions between the sample material and the chemical of interest that can bias measurements in either a negative or positive direction.

Matrix spike: Quality control samples prepared by adding known amounts of contaminants to actual samples, usually prior to processing. Analysis of matrix spikes estimates the bias due to matrix effects.

Method: A body of procedures and techniques for performing an activity systematically presented in the order in which they are to be executed.

Method blank: An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is used to document contamination resulting from the analytical process.

Method detection limit: Minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

Method of standard additions: Addition of three increments of a standard solution (spikes) to sample aliquots of the same size.

Mixing zone: A limited volume of water serving as a zone of initial dilution in the immediate vicinity of a discharge point where receiving waters quality may not meet quality standards or other requirements otherwise applicable to the receiving water.

Practicable: Available and capable of being done, after taking into consideration cost, existing technology and logistics in light of overall project purposes.

Performance evaluation: A type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory.

Precision: Agreement among a set of replicate observations or measurements of the same property, usually obtained under similar conditions, without assumption of knowledge of the true value.

Procedure: Documented set of steps or actions that systematically specifies or describes how an activity is to be performed.

Process: Orderly system of actions that are intended to achieve a desired end or result. Examples of processes include analysis, design, data collection, operation, fabrication, and calculation.

Quality assurance: The total integrated program for assuring the reliability of data. It is a system for integrating the quality planning, quality control, quality assessment, and quality improvement efforts to meet user requirements and defined standards of quality within a stated level of confidence.

Quality assurance project plan: Detailed, project-specific document specifying guidelines and procedures to assure sufficient data of sufficient quality to meet project needs during data collection, analysis, and reporting.

Quality control: The overall system of technical activities for obtaining prescribed standards of performance in the monitoring and measurement process to meet user requirements.

Quality improvement: A management program for improving the quality of operation. Such management programs generally entail a formal mechanism for encouraging worker recommendations with timely management evaluation and feedback or implementation.

Quality management plan: A formal document that describes the quality system in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces for those planning, implementing, and assessing all activities conducted.

Quality system: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability and implementation plan of an organization for ensuring quality in its work processes products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

Reference sediment: A term whose definition applies to the evaluation of dredged material proposed for discharge to the ocean. This term, and "reference site" do not have any legal standing in a 404(b)(1) evaluation at the time this manual is finalized.

Region: An USEPA administrative area.

Regulations: Procedures and concepts published in the Code of Federal Regulations Title 40, Part 230 for evaluating the discharge of dredged material into waters of the United States.

Replicate: One of several identical samples.

Representativeness: The degree to which sample data depict an existing environmental condition. A measure of the total variability associated with sampling and measuring that includes the two major error components: systematic error (bias) and random error.

Sediment: A soil material which has settled on the bottom of a water body. The term *dredged material* refers to sediments which have been dredged from a water body (see definition of dredged material), while the term sediment generally refers to material in a water body prior to the dredging process.

Semivolatile organic compound: Organic compound with moderate vapor pressure that can be extracted from samples using organic solvents and analyzed by gas chromatography.

Sensitivity: Amount of instrument response to a change in sample concentration which can be expressed as the slope of a curve of concentration versus instrument response.

Scope of work: A document used to define work to be performed by a contractor as part of a legally binding agreement.

Spectrometer: Instrument which measures the physical constants of materials (e.g. mass, index of refraction).

Spectrophotometer: Instrument which measures the relative intensities of light absorbed or emitted by chemical species.

Split samples: Aliquots of sample taken from the same container and analyzed independently.

Standard curve: Plot of concentrations of known analyte standards versus the instrument response to the analyte.

Sublethal: Not directly causing death; producing less obvious effects on behavior, biochemical and/or physiological function, histology of organisms.

Surrogate organic compound: Compounds with characteristics similar to those of compounds of interest that are added to all samples prior to processing. They are used to estimate recovery of organic compounds in a sample.

Standard operating procedure: Written document which details the method for an operation, analysis, or action whose mechanisms are thoroughly prescribed techniques and steps, and which is commonly accepted as the method for performing certain routine or repetitive tasks.

Technical systems audit: A thorough, systematic, on-site, qualitative audit of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a system.

Trip blank: Sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures.

Validation: Activity that demonstrates or confirms that a process, item, data set, or service satisfies the requirements defined by the user.

Volatile organic compound: Organic compound with a high vapor pressure that tend to evaporate readily from a sample.

Water quality certification: A statement or affirmation that the proposed discharge of dredged material will comply with applicable State water quality standards.

Water quality standard: Law or regulation that consists of the beneficial designated use or uses of a water body, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an anti-degradation statement.

Waters of the U.S.: In general, all waters landward of the baseline of the territorial sea and the territorial sea. Specifically, all waters defined in Section 230.3(g) of the Guidelines.

Wet weight: Weight of a sample aliquot including moisture (undried).